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# PLANNING THE FUTURE WORKFORCE OF NATURAL SCIENCE RESEARCH COLLECTIONS: A REVIEW OF GRADUATE ACADEMIC PROGRAMS IN THE UNITED STATES

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*Abstract*— Selected literature and Internet sites were used to identify universities that provide graduate academic degrees relevant to the management and care of natural science research collections. Twelve universities with degree programs not dedicated to the arts or humanity fields were selected for closer evaluation. By analyzing the courses offered in museology and the natural sciences at each university, seven universities were identified as currently in a position to provide some level of education and training needed by the future workforce of natural science research collections. However, only two universities stood out as being in the best position to serve most of the academic needs for the entire natural science field. The primary ramification of this situation is that staffing will become a serious challenge for natural science research collections in the near future. To address this challenge universities should re-evaluate programs in natural sciences and museum studies, and develop curriculum standards for museum studies programs.

## INTRODUCTION

A review of recent job announcements for positions in the museum field indicates that a graduate degree in museology, museum studies, or museum sciences is increasingly the expected qualification. The origins of this shift are evident in documents of the American Association of Museums (American Association of Museums, Museum Studies Committee 1978, 1980; American Association of Museums, Professional Practices Committee 1983; Dubberly 1994; Lister 1999), and there are a growing number of programs offering only master's degrees (Adams and Ritzenthaler 1999). While the authors have had the privilege of participating in this growth of the museum field, both have observed that the natural sciences have been only a small part of this trend. Furthermore, the number of training programs and students specializing in the natural sciences has been discouragingly low. This is especially significant given that the growing number of natural science collections (Conference of Directors of Systematics Collections 1971; Mabey and Hoagland 1988) and number of specimens (Howie 1993) exceed the numbers found in other types of collections. In addition, the values and uses of these collections have been expressed many times in different settings (Cohen and Cressey 1969; Duckworth et al. 1993; Genoways et al. 1976; Miller 1985). It is critical that this issue be further investigated, particularly in light of the trends observed with current museum training programs, because the future of these

collections is dependent on having educated and trained staff to provide proper management and care.

In reviewing the management of human resources required for natural science research collections, it is evident that museum training is a relatively new concept, and that many of the existing positions include individuals without such training. In the past, collection positions often were filled with experienced and discipline-trained individuals (Glaser and Zenetou 1996; Reimann 1960; Rodeck 1961); however, this strategy now has limited value in the natural sciences for three reasons. First, the academic changes in higher education are rapidly emphasizing molecular and biotechnological applications at the expense of the functional anatomical and morphometrical approaches (Hoagland and Mabee 1988; Humphrey 1992). Second, the field of museology has evolved over the years, restructuring functions and services of museums, while bringing new philosophies, practices, and standards to collection settings (Kaplan 1992; Lewis 1987; Singleton 1987; Society for the Preservation of Natural History Collections 1994). Finally, many museums will wish to avoid the cost of training new staff members as available resources become more restrictive or prioritized. Museums can actually avoid the cost of training staff, and shift the cost to the individual by hiring students educated through museum studies programs. With these developments, the ability to plan any meaningful academic education or training opportunity in the natural sciences can become a formidable challenge. This issue was acknowledged by the American Association of Museums, Museum Studies Committee (1978) when it stated that “. . . students graduate unaware that they lack proper training and consider themselves ready for museum jobs.” It is proposed that this challenge can be initially addressed by (1) identifying basic academic requirements that serve the management and care of natural science research collections, and then (2) determining which institutions are most able to provide such coursework. This information should be helpful for individuals seeking academic opportunities and for universities in developing appropriate curricula. Equally important is that this information is critical to understanding the nature of the issues facing future staffing for natural science collections.

The issues surrounding the academic education and training needed for the management and care of research collections are complex, especially when one considers the diversity of disciplines included in the natural sciences. The authors have identified critical coursework needed for the management and care of natural science research collections, based on the 30+ years that each has worked with collections and academic programs. The authors consulted knowledgeable colleagues for relevant information to address the needs of less familiar disciplines. With appropriate coursework identified, selected literature and Internet sites were reviewed to identify those universities that come closest to providing the necessary academic opportunities needed to deal effectively with these collections. This information was examined in the context of the direction of training programs and critical issues affecting the future staffing of natural science research collections.

It is intended that this contribution will generate new interest in the future staffing challenges of natural science research collections. Hopefully, this interest will result in meaningful collaborations among academicians, and establishment of curricula to serve the interests of these collections.

## METHODOLOGY

### Selection of courses

There was an initial assumption that anyone seeking a graduate degree involving natural science research collections already would have an undergraduate foundation on which to build. In the biosciences this would include the basics in botany and zoology as well as upper level courses such as anatomy, physiology, genetics, and ecology. In the geosciences, this would include historical geology, physical geology, basic mineralogy, and basic stratigraphy. As with most fields in the natural sciences, academic training in chemistry and introduction to physics would be useful.

Advancing to graduate studies can present opportunities for pursuing multiple academic tracks. There are many recommendations concerning academic requirements for specific collection-related positions (American Association of Museums, Museum Studies Committee 1980; Glaser and Zenetou 1996; Simmons 1993). Williams and Cato (1995) point out the need for a balance and overlap between collection management, care, and use. Simmons (1993: 4) encourages “a degree in a discipline field and a graduate degree in museum studies with an emphasis in museum collections management and training in preventive conservation.” Studies by Cato et al. (1996) determined that the knowledge and skills required for managing natural science collections fall into three broad categories, specifically museology, management, and an appropriate disciplinary specialization. Of these three areas, education and training in museology and a disciplinary specialization are perhaps the most difficult to obtain outside of academic settings. On the other hand, knowledge and skills in management can be acquired through a variety of ways, such as job training, continuing education courses, and appropriately structured museology courses. While the authors acknowledge the need for management training, the focus of this contribution involves the academic programs providing education and training relevant to museology and natural sciences.

To develop a strong academic museology background the authors propose that the critical graduate courses are (1) introduction to museology, (2) museum administration, (3) collection management, (4) preventive conservation, (5) museum law, and (6) information management. An introduction to museology provides the basis for understanding the philosophy, history, functions, and vocabulary of museums, and an overview of the legal, ethical, and professional responsibilities that museum workers bear while they provide a service to their institutions and society. Museum administration addresses legal, ethical, leadership, and operational aspects of museums as multiple resources are developed and utilized to achieve institutional mission and goals. Collection management applies theory and standards of practice while balancing the management, care, and use of collections. Preventive conservation addresses the long-term preservation of collections in terms of materials, environment, handling, storage, and documentation. Museum law is becoming increasingly important as laws and regulations, such as the collection and transportation of wildlife, tax legislation, employee relations, and legal liability, affect all museum operations. A course in information management (for example, biological informatics, data management, environmental data analysis, and object imagery) introduces strategies for efficiently collecting, enhancing, and reporting information relevant to collections.

A strong academic background in museology can be enhanced with any number of other museology courses, such as public programming, field collecting, or collection-based research. However, the six courses listed above seem to be most relevant in serving the needs of natural science research collections.

To develop a useful academic natural science background for the biological sciences, it is proposed that the following bioscience courses be included in a student’s academic program at the advanced undergraduate or graduate level: systematics, evolution, biogeography (or ecology), molecular phylogenetics, and two or more disciplinary specializations (for example, taxonomy of vascular plants, entomology, or mammalogy). A minimum of three of these courses must be taken at the graduate level. Systematics is important in understanding classification systems, nomenclature, natural variation, and application. Evolution is useful in understanding theoretical processes and how they may be represented and interpreted within and among natural populations represented by the collection-based specimens. Biogeography explains patterns of distribution and geographic variation existing in natural populations, while ecology provides the opportunity to study organisms with respect to faunal, floral, and geophysical associations. Molecular phylogenetics provides an appreciation of modern research technology and its implications on the use, management, and care of collections. Finally, the disciplinary specializations allow one to understand the interrelationships of related taxonomic groups, and to start developing a scientific vocabulary for the discipline. There is an advantage in



pursuing multiple disciplinary specializations, but concentrated in groups, such as vertebrates, invertebrates, vascular plants, or non-vascular plants. Increasing the breadth of the student's taxonomic training will be useful for finding future employment involving natural science collections.

To develop a useful academic natural history background for the geosciences, the commonality of paleontology and biosciences must be recognized, thus evolution, and biogeography would be useful. Depending on the paleontological area selected (for example, vertebrates, invertebrates, microfossils, or plants) it would be appropriate to take one or more courses from the selected disciplinary specializations. With respect to paleontology and geology, both would be served with courses in advanced sedimentology. Such a course can develop an understanding and appreciation for the origin, structure, and composition of rock materials. For a specialization in geology, it would be appropriate to substitute the bioscience courses with an advanced course in mineralogy, which is important for the identification and classification of minerals. Once again, these courses must be taken at the advanced undergraduate or graduate level, with a minimum of half being taken at the graduate level.

## Selection of Programs

With so many universities providing graduate academic programs, the challenge is identifying those that offer the relevant coursework needed for both museology and the selected field of natural sciences. The initial search focused on programs providing graduate degrees in museology because the universities with museum programs are considerably fewer than those having programs for the natural sciences. Potential programs were identified using previous work by Adams and Ritzenthaler (1999) and Genoways (1989).

## Evaluation of Programs

Museum programs were evaluated on the ability (1) to offer a graduate degree, and (2) to offer courses that serve the interests of natural science collections. Programs that obviously were dedicated to specific fields related to the arts and humanities (for example, art, art administration, history, historic preservation, and anthropology) were eliminated from the list.

After the list of possible institutions was compiled, the Internet was used to visit websites of the selected museum programs to acquire additional information such as contacts for additional inquiry, program administration, graduate degree offered, and course descriptions. Next, the home-page of each university was used to locate the academic component responsible for providing coursework in the natural sciences.

Considerable leniency was used in the interpretation of course content based on course titles and descriptions because changes may occur rapidly. For instance, no separation or preference was given to courses presented as a combination with related topics, or as an "Introduction to . . ." or "Seminar on . . ." a specific topic, versus a topic supported with an obviously more structured course. If there was insufficient information to allow reasonable determination of actual course offerings, or if relevant information was exceedingly difficult to locate at a given website, the course was assumed to be lacking from the respective program.

Academic numbering systems typically are used to separate lower level and upper level coursework, often differentiating the undergraduate courses from graduate courses. However, such systems differ among universities and their application for undergraduate and graduate coursework can vary considerably. For example, it is not uncommon for upper-level undergraduate courses to serve graduate-level requirements. Because of uncertainties related to different academic policies, program development, and variations in numbering systems, no distinction was made between graduate or undergraduate courses, with the understanding that these courses may be available to both groups of students under certain conditions.

Initially universities were placed in one of three groups depending on their ability to provide the basic museology courses deemed important for the management and care of natural science research collections. Universities in Group 1 offer all six museology courses. Group 2 universities offer at least half of the six courses, whereas universities in Group 3 offer fewer than half of the six courses.

Because it is conceivable that an institution can be a leader in one sector of the natural sciences (for example, biosciences) and be lacking in another sector (for example, geosciences), the natural sciences were subdivided into vertebrate zoology, invertebrate zoology, botany, vertebrate paleontology, invertebrate paleontology, paleobotany, and geology. Each subdivision was evaluated at each university and scored as adequate (A), provisional (P), or inadequate (I), depending on the number of relevant courses offered in respective sectors of the natural sciences. Institutions that did not offer courses within a subdivision were indicated as "not applicable" (NA). These scores were tabulated for comparative purposes.

For the biological fields (vertebrate zoology, invertebrate zoology, and botany), universities providing six or more courses supporting the subdivision, ideally including systematics, evolution, biogeography (or ecology), molecular phylogenetics, and at least two discipline-specific courses, were regarded as adequate. Those having four or five of the six courses were regarded as provisional, and those having three or less were regarded to be inadequate.

For the paleontological fields (vertebrate paleontology, invertebrate paleontology, and paleobotany), those universities providing evolution, biogeography, sedimentology, and at least one discipline-specific course were regarded as adequate. Those lacking one of the courses were regarded as provisional, and those lacking two of the courses were regarded as inadequate.

For geology, a university was rated as adequate if courses were available for both rocks and minerals, such as mineralogy, petrology, and sedimentology. Provisional universities had courses for rocks, but not minerals.

A correlation between the strength in museology courses and the strength of various sectors of the natural sciences provided a means of identifying universities best situated for contributing to the future staffing of the natural science research collections. Equally important, it provided a valuable resource for giving direction to universities on ways to strengthen their own programs, and to potential students in making decisions about what universities to attend for careers that involve natural science collections.

## RESULTS

The primary resource for finding institutions was the *Guide to Museum Studies and Training in the United States*, which lists 94 institutions having programs for museum studies (Adams and Ritzenthaler 1999). Of this total, 69 programs (73.4%) are dedicated to disciplines (33 art, 17 history, six anthropology, nine humanities combinations, and four specialized fields, such as administration) that tend to exclude the natural sciences. Of the remaining 25 institutions, 12 offer classes and graduate degree programs, six offer classes and certificate programs, six offer only classes, and one serves only undergraduate studies. From this list, the 12 universities offering graduate degree programs in museum studies were selected as the best options for serving the education and training needs for natural science research collections. Listed alphabetically by state these universities include John F. Kennedy University, San Francisco State University, University of Colorado-Boulder, George Washington University, University of Florida, Southern Illinois University, University of Kansas, University of Nebraska-Lincoln, New York University, University of Oklahoma, Baylor University, and Texas Tech University.

Genoways (1989: 77) identified 18 universities that had the potential to "provide training in the management of biological, geological and anthropological collections." Eight of these universities include those derived from Adams and Ritzenthaler (1999), specifically John F. Kennedy University, San Francisco State

University, George Washington University, University of Kansas, University of Nebraska-Lincoln, University of Oklahoma, Baylor University, and Texas Tech University. Nine other programs listed by Genoways (1989) were not included in the current study because of possible discontinuation (Oregon State University), limited program offerings (University of Alaska-Fairbanks and Texas A & M University), or dedication to disciplines that tend to exclude natural sciences (Arizona State University, University of Arizona, California State University-San Bernadino, University of Denver, Indiana University, and University of Washington). The only university left from those listed by Genoways (1989) is the University of Iowa. It was added to the list of universities deserving further evaluation because it is one of the oldest museum studies programs in the country and it includes at least a certificate program (Adams and Ritzenthaler 1999). However, the University of Nebraska-Lincoln was dropped from the list because the university administration made decisions to end the program. As a result, the current study identified 12 universities (Table 1) with the potential to serve the needs of natural science research collections.

The 12 universities were divided among the three groups according to the critical courses in museology offered, and within each group universities were listed alphabetically by state (Table 2). Three universities were listed in Group 1 because they offered all six museology courses regarded as important in serving the interests of natural science collections – San Francisco State University, George Washington University, and Texas Tech University. Group 2 universities, providing more than half of the six courses, included John F. Kennedy University, University of Iowa, New York University, Baylor University, University of Kansas, and University of Colorado-Boulder. The University of Florida, Southern Illinois University, and Oklahoma University were placed in Group 3 for having less than half of the six critical courses.

Table 3 summarizes the academic patterns for relevant disciplinary courses of the 13 universities examined in the current study. Only nine universities are providing critical museology courses. Of these nine, two universities (John F. Kennedy University and New York University) offer little or no coursework in natural science fields. Of the remaining seven, a comparison of all course offerings in museology, biosciences, and geosciences shows San Francisco State University and University of Kansas to be in the best position to provide education and training to the future workforce of natural science research collections. While George Washington and Texas Tech University were regarded strong in museology, their ability to serve the future workforce is limited to specific areas of the natural sciences. Similarly, the University of Florida and Southern Illinois University offer strong bioscience programs, and the University of Iowa and University of Colorado offer strong geoscience programs, but all have museology programs that lack important coursework considered relevant for the future workforce.

## DISCUSSION

A major challenge in recommending academic strategies suitable for jobs in research collections is demonstrating the benefits of such academic training over more traditional approaches. Traditional approaches typically emphasize a specialized disciplinary education combined with a possible student-professor mentorship and an apprenticeship (Simmons 1993; Singleton 1983, 1987; Waller 1974). The problem is that some individuals in high-ranking museum positions tend to perpetuate certain attitudes about training in museology (Burcaw 1969; Parr 1964; Rodeck 1961). As a result, individuals “. . . in high positions representing the one tradition make sure that those hired are in the same tradition” (Washburn 1967: 46). The best remedy for this challenge is to educate individuals having traditional backgrounds to the fact that training in museology provides significantly greater benefits for collections and institutions than other alternatives. There is growing evidence demonstrating that formal education and training in museology, combined with selected disciplinary

TABLE 1. Universities in the United States with museology programs that might be incorporated with bioscience and geoscience programs to prepare individuals for careers in natural science research collections.

UNIVERSITY (Year initiated)	DEGREE OFFERED	CONTACT
John F. Kennedy University (1974)	MA	John F. Kennedy University; 12 Altarinda Road; Orinda, California 94563-2603; 925-254-0200; www.jfku.edu/libarts/mms-req.html
San Francisco State University (1987)	MA	Graduate Admission Office; NAD 254; 1600 Holloway Avenue; San Francisco State University; San Francisco, California 94132; 415-338-1612; www.sfsu.edu/~museumst/about.html
University of Colorado, Boulder (1960s)	MS	Museum and Field Studies Program; 218 UCB; University of Colorado, Boulder; Boulder, Colorado 80309-0218; 303-492-5437; www.colorado.edu/CUMUSEUM/MFS/Index.html
George Washington University (1976)	MA	Museum Studies Program; 2035 F Street, NW; George Washington University; Washington, D.C. 20052; 202-994-7030; www.gwu.edu/~mstd/index2.html
University of Florida (1986)	MA	School of Art and Art History; P.O. Box 115801; Gainesville, Florida 32611-5801; 352-392-0211 X201; www.arts.ufl.edu/art/mstudies.html
Southern Illinois University (1975)	BA / BS (minor only)	Museum Studies Program; University Museum; Southern Illinois University; Mail Code: 4508; Carbondale, Illinois 62901; 618-453-5388; www.museum.siu.edu/university_museum/edication/m_s_program.htm
University of Iowa (1910)	BA / MA (minor only)	Museum Studies Program; University of Iowa; 10 Macbride Hall; Iowa City, Iowa 52242; 319-335-0481; www.uiowa.edu/~museum/courses.htm
University of Kansas (1981)	MA	Historical Administration and Museum Studies, Dyche Hall, University of Kansas; 1345 Jayhawk Blvd.; Lawrence, Kansas 66045-7501; 785-864-4508; www.ukans.edu
New York University (1977)	MA / MS	minor only) Museum Studies Program: Graduate School of Arts and Sciences; 19 University Place; Suite 308; New York, New York 10003; 212-998-1977; www.nyu.edu/gsas/program/museum/courses.html
University of Oklahoma (1987)	MLS	College of Liberal Studies; University of Oklahoma, 1700 Asp Avenue, Suite 226, Norman, Oklahoma 73072-6400; 405-325-1061; www.ou.edu/cls/mlsinquirer/mlsbulletin.html
Baylor University (1993)	BA / BS MA	Department of Museum Studies; P. O. Box 97154; Baylor University; Waco, Texas 76798-7154; 254-710- 4349; www.baylor.edu/Museum_Studies
Texas Tech University (1974)	MA	Museum Science Program; Texas Tech University; Box 43191; Lubbock, Texas 79409-3191; 806-742-2442; www.ttu.edu/~offpub/GradISMUSM.html

TABLE 2. Museology courses, relevant to the management and care of natural science research courses, offered at universities compared in this study.

Universities are listed according to the number of graduate museology courses offered, and then alphabetically by state.

UNIVERSITIES	MUSEOLOGY	COLLECTION MANAGEMENT	COLLECTION CARE	MUSEUM ADMINISTRATION	INFORMATION MANAGEMENT	MUSEUM LAW
San Francisco State University	X	X	X	X	X	X
George Washington University	X	X	X	X	X	X
Texas Tech University	X	X	X	X	X	X
John F. Kennedy University	X	X	X	X	X	-
University of Iowa	X	X	X	X	X	-
New York University	X	X	X	X	X	-
Baylor University	X	X	X	X	-	X
University of Kansas	X	X	X	X	-	-
University of Colorado, Boulder	X	X	-	X	-	-
University of Florida	X	X	-	-	-	-
Southern Illinois University	-	X	-	-	X	-
University of Oklahoma	X	-	-	-	-	-

TABLE 3. Summary of the rankings of university strength in various fields of the natural sciences based on criteria described in the text. Universities are initially grouped according to strength in museology (see Table 2), and then scored as A (adequate), P (provisional), I (inadequate), or NA (not applicable) for the broad field designated.

UNIVERSITIES	Museology	BIOSCIENCES			GEOSCIENCES			
		Vertebrate Zoology	Invertebrate Zoology	Botany	Vertebrate Paleontology	Invertebrate Paleontology	Paleobotany	Geology
GROUP 1								
San Francisco State University	A	P	A	A	A	A	A	A
George Washington University	A	P	P	P	A	A	P	A
Texas Tech University	A	A	P	P	A	P	P	P
GROUP 2								
John F. Kennedy University	P	NA	NA	NA	NA	NA	NA	NA
University of Iowa	P	P	P	A	A	A	A	A
New York University	P	I	NA	NA	I	I	I	NA
Baylor University	P	A	P	P	A	A	P	P
University of Kansas	P	A	A	A	A	A	A	A
University of Colorado	P	A	P	P	A	A	A	A
GROUP 3								
University of Florida	I	A	P	A	A	P	A	A
Southern Illinois University	I	A	A	P	I	P	P	A
University of Oklahoma	I	A	P	P	A	A	P	P

courses, can provide a better future for natural science research collections (Cato et al. 1996; Simmons 1993; Williams 1999). The primary benefits are that the process is more efficient, and the product is more comprehensive. For example, traditional approaches often do not address issues such as an appreciation for institutional goals and mission, laws, ethics, and professional standards, preservation and research integrity, changing needs of collections, and new approaches to collection management, care, and use.

## Institutional Mission and Goals

Working concepts supporting museology recognize that collections should serve the mission and goals of the institution (Malaro 1994; Ullberg and Lind 1989) and ultimately the interests of society as a whole (Hoagland 1989; Laub 1985; Singleton 1983, 1987; Tramposch 1994). While acknowledging the importance of the scientific community within a museum setting, Rodeck (1961: 75) stated:

Our best museologists . . . [understand] . . . the museum's point of view and methods, and with an appreciation of how these have been applied by differing institutions for varying purposes, have succeeded in shaping an institution that utilizes scientific knowledge, academic insight, historical perspective, artistic and technical skills, and advertising psychology, all woven together in a an atmosphere of social consciousness.

Laub (1985: 53–54) adds to this perspective with his comment that “a person who has no sense of responsibility for the care of collections, is disorganized, is uncomfortable with the public, and has no interest in exhibition and educational work is hardly suitable for curatorial work.” More understanding and loyalty to institutional mission and goals, and perhaps less emphasis on disciplinary interests, represent a fundamental quality of those who have received formal academic education and training in museology.

## Laws, Ethics, and Professional Standards

Almost all museums must serve the public because they are either governmental institutions or they are non-profit institutions (for example, those having 501.c.3 or 170.c.1 status) that receive governmental benefits, such as freedom from taxation, ability to provide tax deductions for donations, and access to special funding. As a result, museum boards, administrators, and collection workers are exposed to a growing number of legal, ethical, and professional accountabilities that are intended to insure that museum and collection services continue in the future (Malaro 1994; Ullberg and Lind 1989). However, in recent years these legal, ethical, and professional matters have expanded beyond public services to include other operations, such as acquisitions, possession, health and safety, environment, social rights, and cultural concerns (Malaro 1998; Phelan 1994). An awareness of and compliance with these issues are fundamental to standard museology education and training.

## Preservation and Research Integrity

Walker (1963: 293) encouraged that “. . . there be a greater willingness to accept change in collection care . . . and . . . that the problems of collection care be attacked with more imagination.” He further commented that “we happily claim that we are preserving study materials for posterity, but we are doing very little to insure that these materials will last or be of value in the distant future” (Walker 1963: 294). Four decades later, Williams (1999) pointed out that these traditional problems continue, and that the failure to document preservation methods and apply the same scientific scrutiny to preservation practices as to other research, compromises the future use of collections. While high disciplinary standards of conducting research often have



not been incorporated in museum practices, similarly, the high professional standards of museum practices (Grinnell 1922) often are not incorporated in the modern research of the scientific disciplines. Modern research is less reliant on whole organisms represented by museum collections, with researchers often relying on tissues or other samples that they have not collected (Hoagland and Mabee 1988; Humphrey 1992). A growing number of publications fail to document voucher specimens and collections on which research is based (Reynolds et al. 1996; Yates 1985; Yates et al. 1996). Finally, as new data and research material becomes available, it often is not incorporated with existing collections or even given the same level of professional management and care afforded such collections (Baker 1988; Dessauer and Hafner 1984; Frey et al. 1992; Gardner 1996; Yates 1996). The lack of proper management and care of collection resources resulting from these issues negatively affects the ability of museum administrators to build support for collections. Eventually, the integrity of the research also is compromised because of the inability to replicate the work (Genoways 1988). Clearly such factors, do not serve the interests of the institution's mission and goals, nor do they reflect responsible legal, ethical, and professional behavior.

## Changing Needs of Collections

The "complexity of collections, research techniques and collection care are such that one person can no longer do justice to both collections management and full-time systematics research" (Simmons 1993: 3). Obviously, this has led to the recognition of the number and diversity of tasks in collection positions (Cato 1991; Cato et al. 1996; Glaser and Zenetou 1996; Humphrey 1992; Simmons 1993; Williams and Cato 1995). The roles and responsibilities of such positions have evolved substantially in recent years (Simmons 1993). Collection management and care have evolved with museology, whereas collection use has evolved with disciplinary processes (Williams 1999). As a result, the body of knowledge about collections care has expanded (Lewis 1987), and operations have changed significantly to meet the needs of collection use. Academic training in museology can improve collection operations by providing familiarity with new technological applications, preservation practices, and management strategies.

## New Philosophies about Collections

Simmons (1993: 4; see also Williams et al. 1977) stated that:

oral traditions, autonomy, and on-the-job training are responsible, in part, for a crisis in natural history museums today – a crisis of too many specimens for the staff to care for, of not enough training available for the staff, and specimens deteriorating because of inadequate environmental conditions and a lack of knowledge about how to deal with many problems.

The Society for the Preservation of Natural History Collections has aggressively promoted research in collection management and care by crossing disciplinary, national, and professional boundaries to build broadly representative alliances where knowledge, ideas, and resources can be shared and developed. The resulting new philosophies are evident in recent literature (for example, Duckworth et al. 1993; Rose and Torres 1992; Rose et al. 1995; Williams 1999). Furthermore, they are being incorporated into collection operations, thus serving all collection functions while strategically balancing available resources. Examples of these changing philosophies range from major restructuring, such as that done at the Canadian Museum of Nature (Emery 1993; Fitzgerald and Colgan 1992), to simple application of new perspectives to managing collections (McGinley 1992; Williams et al. 1996). In many cases, evidence of this changing philosophy also appears as staff

members make choices about where to publish their research and what professional meetings to attend.

It is clear that having a collection staff with formal education and training in museology is an important step to serving an institution's mission with respect to collections. Because collection issues are becoming increasing more complex and demanding, it is unreasonable to believe that any individual without proper training, whether they be a disciplined-trained researcher or a volunteer, could effectively serve the long-term needs of natural science research collections.

In reviewing and comparing the academic museum programs, it is obvious that there is minimal standardization in departmental jurisdiction, academic focus, curricula, course combinations, course titles, or numbering systems, as would be expected among universities. This point has previously been noted by the American Association of Museums, Museum Studies Committee (1980). This situation can be attributed in part to factors such as university history, geographical location, and faculty specializations. However, for museology programs there are a few idiosyncrasies, such as undergraduate versus graduate education, degrees versus certificates, and majors versus minors, that clearly can differentiate programs from one another. The current study made some assumptions about programs and curricula because of intentions of serving the interests of the student, the hiring institution, and ultimately the professional development of the museum field.

As previously stated, there is an assumption that anyone seeking to work with natural science research collections already will have the basic disciplinary undergraduate coursework, as well as upper level courses. The importance of graduate studies often is expected among the sciences, but the museum community also recognizes that a graduate degree is expected for professional positions in the museum field (American Association of Museums, Museum Studies Committee 1978, 1980; American Association of Museums, Professional Practices Committee 1983; Genoways 1989; Simmons 1993). Genoways (1989: 79) was more specific in referencing collection support positions, stating that the "Master's degree should be recognized as a terminal degree by universities, museums, and the profession." Experience has shown that graduate education provides a higher level of specialized training, accommodates necessary intensity and rigor for such training, and often creates unique opportunities that would not be available at the undergraduate level because of time restrictions or numbers of students involved. Also, graduate programs usually do not involve the greater numbers of courses covering a broader range of subjects that is typical of undergraduate programs.

It is acknowledged that a degree is academically and professionally more desirable than a certificate, thus a certificate is not an appropriate substitute to a degree. Furthermore, a certificate has little or no value if it does not adequately satisfy basic academic standards. However, if an academic certificate program maintains the same academic rigor and expectations, as well as university over-sight that would be found with a graduate degree program, a certificate can be appropriate and relevant for certain situations. In such cases, the certificate provides a meaningful recognition of a specialized academic accomplishment equivalent to perhaps an expanded minor (for example, 15–18 credit hours). Because such recognition does not require the completion of a full degree, not to mention the associated resources, it is might be most applicable for individuals having, or working on, a related graduate degree. It is possible that a certificate in museum studies in conjunction with a master's degree in natural science can provide the necessary academic training needed for an individual pursuing a career in managing and caring for research collections. A certificate program also can enhance the skills of long-practicing members of the profession who lack advanced academic degrees.

As museum job qualifications increasingly specify graduate degrees, individuals with anything less can expect to be less competitive for such employment. However, there remains a question as to whether an individual is better qualified by having a graduate degree in museology or natural sciences. The American Association of Museums stresses the need for flexibility in the emphasis of education and training of museum professionals (American Association of Museums, Museum Studies Committee 1978, 1980; American

Association of Museums, Professional Practices Committee 1983). With this in mind, it is conceivable that an individual could major in natural sciences and minor in museology, or *vice versa*. Ultimately, this issue will be resolved based on the degree requirements and curriculum options of the program, combined with the career goals and resources of the individual. However, it is reiterated that it is difficult to serve the interests of research collections with training in only one field and not the other. The natural sciences are needed for understanding the collections with respect to purpose and process, whereas museology is needed for understanding the museum as a functioning organization where collections are the resources, or products, requiring management and care.

Students also should be aware of various degree and educational options. For example, the Southern Illinois University is listed in Adams and Ritzenthaler (1999) as providing a graduate degree; however, closer evaluation would show that the graduate degree is not for museum studies. Also, the museum studies program itself is offered only at the undergraduate level, yet some museum studies courses (for example, collection management and information management) are provided at the graduate level within natural sciences. Faced with all of these choices, students must decide for themselves which program best serves their means and career goals (Schwartzter 2001). As educators, the authors believe that the more education one receives the better prepared the individual will be, but because everyone has finite resources (i.e., funds, time, opportunity), there is considerable benefit in carefully planning academic and professional careers.

Any student with an interest in natural science research collections should focus on the universities having strong programs in museology and the natural science field of their interest (see Table 3). If relocation is a problem, it may be possible to structure coursework and opportunities to serve the interests of the student. For example, as long as receiving a formal degree is not a problem, the museology courses may be acquired at one university and the natural science courses may be acquired at another university.

There is little doubt that academicians would debate the intricacies of course selections that would best serve the needs of research collections, but there are various parameters that tend to restrict viable options. The most limiting factor is the total number of academic hours that can be required of any degree or certificate program. Similarly, course selection at any given institution can be equally limiting. In this particular study, museum law was regarded as relevant, but less than half of the programs provide any formal coursework. Also, subject material can be quite diversified. Recognizing the fact that most programs address information management in one way or another, the variety of course titles required some flexibility on the part of the authors; for example, "Documentation of Collections" (John F. Kennedy University), "Information Technology in Museums" (San Francisco State University), "Museum Documentation" (New York University), and "Museum Data Management" (Texas Tech University).

The current study differs significantly from previous listings of training programs (for example, Adams and Davis 1997; Adams and Ritzenthaler 1999; Anderson and Fogg 1988; Burcaw 1969; Dubberly 1994; Genoways 1989) in that it has attempted to precisely define academic options most useful for serving an important component of the museum community. However, the inconsistencies observed among programs and courses demonstrate a need for some standardization among programs and curricula, particularly if programs are collectively going to serve the needs of these collections. Waller (1974: 28) noted that

training programs by and large have not clearly articulated the principles and premises on which they are based and the specific purposes for which they exist. Consequently, it is difficult for the prospective student to decide which program best suits his own aims and needs.

For the natural sciences, good quality textbooks, established subject matter, and credentials of instructors provide some assurances of course content and academic rigor; however, these resources and data are not available for museology programs. Therefore, prospective students making decisions about programs must rely on their own critical review, with the aide of professional guidelines (Adams and Davis 1997; Adams and Ritzenthaler 1999; Anderson and Fogg 1988; Burcaw 1969; Dubberly 1994; Genoways 1989; Schwartz 2001).

This study demonstrates that there is justification for concern about the availability of educational programs that serve the academic requirements for managing and caring for natural science research collections. Only seven (7.5%) of 93 graduate museum studies programs seem to be in any position to take on part of the task of educating and training future workers in natural science research collections (Table 3). Although it is remotely conceivable that these programs might be able collectively to fulfill the future staffing needs of these collections, it is troubling that the arts and humanities have a much greater number of programs to accomplish the same task for their fields. Also, it must be realized that each of the programs identified in the current study may have other priorities that may not emphasize natural science research collections. This is evinced by the low number of natural science graduates entering the museum field each year.

While no more than seven programs identified in this study are positioned to partially serve the education and training needs for research collections, it is important to realize that several other universities might be added to the list with appropriate administrative decisions and actions. These institutions are encouraged to expand their programs to assist with these needs because it is unlikely that the top institutions will be able to train all future staff needed for natural science collections.

It is apparent that the staffing of natural science research collections will become a serious challenge for the museum community in the near future. To mitigate this situation it is recommended that universities seize the opportunity and re-evaluate their programs in the fields of natural science and museology to improve the services and graduate degree options that they offer. The authors suggest that the American Association of Museums lead an attempt to reach a high level of academic standardization among training programs for the benefit of all.

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