Workshop to Produce a Decadal Vision for Taxonomy and Natural History Collections

Report to the

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Introduction

Fifty-nine representatives from 48 institutions and representing 31 scientific societies and agencies (Appendix I) met in Gainesville, FL, on 10-12 November 2003 to consider the future of taxonomy and natural history collections in the United States. The workshop was funded by the Biodiversity Surveys and Inventories Program of the Division of Environmental Biology of the U.S. National Science Foundation and hosted by the Florida Museum of Natural History. Most of the 59 participants were nominated by presidents of taxon-oriented societies; this strategy diversified the attendance beyond that which would be selected by a small group of workshop organizers. Additional participants were selected to increase the geographic, demographic and institutional diversity, as well as the taxonomic expertise of attendees. In addition to the workshop participants, about 30 students, faculty, and employees from the University of Florida attended as observers.

The format of the workshop consisted of seven presentations to review the goals of the workshop and other relevant topics followed by a series of breakout sessions to address specific questions. After each breakout, the participants returned to the main meeting room and summarized their discussions. On the last day of the workshop, recommendations were agreed upon and an implementation strategy was developed.

Why the Workshop was Needed

Although thousands of taxonomists belong to taxon-focused societies, and many work at institutions with natural history collections, they have had little influence on the priorities of the national research agenda in the biological sciences. Throughout the U.S., many natural history collections are being forced to scale back their programs or, in extreme cases, close their doors (Black, 1984; Tirrell, 2001). Some of these cuts are attributable to short-term fiscal crises, but others appear to be the result of administrators moving away from natural history and organismal biology (Gropp, 2003; Suarez and Tsutsui, 2004).

Natural history collections are facing serious financial challenges in spite of the conclusions of several important and widely circulated reports that the results of taxonomic and systematic research are fundamental to addressing many scientific and societal needs, including the development of strategies for countering the loss of biodiversity (e.g., National Science Board, 1989; Systematics Agenda 2000, 1994).

Other recent workshops and publications recognized major research questions that must be addressed and identified important societal benefits that accrue with knowledge resulting from taxonomic research and natural history collections. For example, Systematics Agenda 2000 (Claridge, 1995) clearly articulated the core missions of taxonomy (to inventory the species diversity of the globe, to produce a predictive classification of life, and to organize this information into an efficiently retrievable form). However, these sources rarely emphasized the fundamental connection between taxonomic research and natural history collections.

It is incumbent upon organismal biologists, and systematists in particular, to speak with a unified and effective voice in explaining the value of taxonomy and biological collections in documenting the history and health of the planet and in protecting and managing biological resources. With environmental deterioration proceeding rapidly, little time remains for documenting the world's biodiversity, and taxonomy and natural history collections remain the core resources for accomplishing this extremely important task. Most work on species-level taxonomy is necessarily specimen-based and is likely to remain that way. Collections of specimens are necessary for the fulfillment of the research and societal benefits identified below.

Goals and Topics Addressed

The goals of the workshop were to:
(a) Identify the major research questions that must be addressed with knowledge resulting from taxonomic research and natural history collections.
(b) Identify important societal benefits that accrue from taxonomic research and natural history collections.
(c) Produce a 10-year vision for taxonomy and natural history collections, and develop a plan to meet the priorities of that vision.
(d) Communicate the results and recommendations of the workshop participants to scientists, administrators, and policy makers.
(e) Consider the utility of an ad-hoc overarching umbrella organization in providing an effective voice for the taxonomic community and in facilitating and monitoring progress on recommendations made by participants of the workshop.

Results

The principal conclusions of the workshop emphasized the importance of natural history collections to science and society:

1. Natural history collections contain a vast amount of biological information that exists in no other form or place and that cost the nation billions of dollars and centuries of effort to amass. The U.S. holds by far the greatest number of natural history collections of any country in the world.
2. Many of the specimens and ancillary data in collections were obtained prior to major modifications of the landscape that have characterized modern development and, consequently, are an irreplaceable record of our natural heritage. This information is fundamental to understanding the natural and cultural history of our nation and the world and, as such must be maintained in perpetuity.
3. The information needed to accomplish major scientific goals and provide important societal benefits (identified below) is contained in natural history collections. These goals and benefits are unrealized because natural history collections are not managed (or even properly recognized) as a national resource.
4. The solution to the unrealized potential of natural history collections is to view them as a single entity, i.e., as a network of biological observatories distributed across the nation and with a database that is continually increasing in quantity, quality, and scientific value; hereafter referred to as LINNE = Legacy Infrastructure Network for Natural Environments.

Creating an interactive and linked network of biological observatories will substantially increase the amount of available information on the geographic and temporal distributions of organisms and significantly enhance the ability of taxonomists to identify and describe species, and of phylogeneticists to ascertain relationships among species. As better taxonomic and phylogenetic information becomes available, the scientific community will be better able to:

1. Conduct research on environmental issues such as human health, climate change, and invasive species.
2. Improve our understanding of the history of life and our ability to address questions in comparative biology such as those related to the origin and maintenance of clades and biogeographic patterns, and the evolution of infectious diseases.
3. Recognize important new areas of scientific research such as those related to biosecurity and biotechnology.

4. Provide information instantly on species distributions, species associations, habitat preferences, and other data required by ecologists and conservationists, and by public health workers attempting to respond effectively to emerging human pathogens.

Creation of LINNE

The United States currently is unable to realize certain scientific and societal benefits because natural history collections—the repositories of the fundamental data of nature—are underfunded, understaffed, and underutilized. This situation exists because collections are maintained and managed as separate institutional properties, where each collection has only a small role to play in scientific investigation, and where data are difficult to extract and manage. Instead, natural history collections must be recognized as unique sources of significant scientific data and their full potential will only be realized when they are managed as components of one vast network of information (LINNE). When the natural history collections of the nation are linked together in an interactive system and managed as one large and easily accessed source of biological data, science and society will be able to move forward in a much more productive, expeditious, and efficient manner. A particularly significant result of LINNE will be that research will be able to be conducted on a national or continental scale rather than on smaller and less scientifically significant geographic areas as now often is done.

Most of the infrastructure necessary to create LINNE is in place in the form of natural history collections housed in universities and museums. This system of collections, the foundation for LINNE, is distributed throughout the U.S., with several nodes located in every state. This vast national collection resource has been built with private and public funds over a period of almost 200 years at an enormous cost.

Although the basic infrastructure for LINNE is in place, the information in collections is often largely unavailable, even to researchers. Herculean efforts are required for individuals to extract information from the many collections where data are not available in electronic form. Some collections have not even received sufficient curatorial attention to be readily accessible. Attention to the following areas is necessary to maximize the availability of information and fully realize the potential of LINNE.

1. **Modernize collection facilities.** To maximize the usefulness of natural history collections, ancillary collections (such as libraries, photographs, digital images, plant and animal tissues, and field notes), and associated databases and to guarantee their long-term survival, funds are necessary for the improvement of collection facilities across the nation and for technical assistance to manage the facilities. Although the emphasis today often is on "information transfer" and electronic databases, specimens always harbor much more data than can be displayed electronically. It is thus vital to emphasize the source of information – the specimens themselves - and not just currently available data. Examples of the needs for collections include better and safer storage facilities that meet OSHA and International Fire Code requirements (fire-resistant cabinets, space-saving compactors, etc.), replacement of poor storage media (diluted or improper preservatives, non-acid free herbarium sheets, etc.) and deteriorating labels with archival quality labels, and more collection managers and technicians to care for collections, catalog specimens, and database locality and other specimen data. Ancillary collections such as photographic slides and film, digital images, plant and animal tissue collected for DNA research, field notebooks, libraries, etc. also have to be included in any plan. Collection management must emphasize conservation of materials (Rose and Hawks, 1995).

In addition to an initial infusion of funds to improve collection facilities and staffing needs, the annual budget of NSF's Biological Research Collections Program (BRC) should be increased to $20 million as soon as possible. This increase is necessary to reverse the situation of inadequate housing and staffing for the nation's natural history

collections that ultimately will lead to their loss or that will continue to make these resources only minimally accessible. The program also should more strongly encourage research on improved methods for long-term storage of specimens and ancillary collections. Increasing the budget of BRC sustains the process of peer-review in identifying the most critical areas for new federal investment in natural science collections.

2. **Update and verify specimen identifications.** Accurate identification of specimens in natural history collections is necessary for all research related to the spatial and temporal distributions of organisms. Misidentified specimens can lead to misinformed and inaccurate recommendations on endangered species, invasive species, human disease vectors, agents of bioterrorism, and other matters important to national security or scientific efficiency. Because of the insufficient number of taxonomists in the U.S. and around the world**,** many specimens in museums now are unidentified or incorrectly identified (estimates by workshop participants of misidentified specimens were 10-60% depending on the taxonomic group). This dire situation exists because too few taxonomists are available to identify specimens and keep names up to date as new descriptions appear. Funds must be made available to enable taxonomists to visit collections and update specimen identifications, and to train new taxonomists as experts on groups of organisms for which insufficient expertise exists. The failure of support for taxonomy to keep pace with the growing need for credible taxonomic information impedes our ability to conserve, manage, and understand the natural world (Wheeler et al., 2004).

3. **Expand the electronic availability of data**. The great proportion of the taxonomic, geographic and other information available on specimens in collections remains non-databased and unavailable to researchers and educators. Publications based on data extracted from these specimens provide an important source of information to science and society, but only a fraction of the total amount of information available from the millions of specimens and associated data residing in institutional collections can be readily utilized at present. Additional information needs to be databased, and all possible information must be made readily available on the internet. The nation's collections represent the most underutilized scientific resource in existence.

[A workshop entitled, "Development of a National Systematics Infrastructure: A Virtual Instrument for the 21st Century," was held at the New York Botanical Garden on 11-13 December 2003, to address the cyberinfrastructure necessary for the efficient distribution of data from natural history collections and other taxonomically relevant data. This topic was not specifically addressed at the Florida workshop.]

Recent Initiatives at NSF

Participants of the workshop unanimously expressed strong support for recent initiatives at NSF that enhance our nation's taxonomic expertise and our knowledge of biodiversity, including:

- **Partnerships for Enhancing Expertise in Taxonomy (PEET)**
- **Planetary Biodiversity Inventories (PBI)**
- **Revisionary Syntheses in Systematics (RevSys)**
- **Assembling the Tree of Life (AToL)**

These initiatives support student training, public outreach, and collecting, vouchering, and describing species-level diversity, as well as deciphering phylogenetic relationships of all forms of life on Earth, from microbes to mammals. Collectively, they encourage and support expeditionary work to document biotic diversity in poorly known environments and, by doing so, represent an extremely timely and important response by NSF to the biodiversity crisis and the scientific community's concern about the urgent

need to document our natural heritage. Habitats are being lost, species are going extinct at an unprecedented rate, and the time remaining to document the biodiversity of our planet is very short. As the landscape of the United States, and that of much of the world, undergoes massive change, documentation of the impact of this change resides in collections built through projects supported in large part by programs of the National Science Foundation. Documentation of Earth's biological diversity must be completed in the next few decades or much of the products of billions of years of evolution will disappear without being recorded or analyzed. Lost with that diversity will be not only the history of our biological world, but also a multitude of opportunities to develop new foods, medicines, biocontrol strategies for pests, and other products that benefit humans. It is imperative that these initiatives continue and be expanded to the fullest extent possible if we are to meet the challenges of the biodiversity crisis and realize societal benefits. **Workshop participants strongly recommend that these initiatives achieve permanent status at NSF comparable to that of Systematic Biology, Long-Term Ecological Research, and other major programs. Given the urgency of discovering and describing our disappearing biodiversity, funding for these initiatives should be increased immediately to the fullest extent possible.**

Biological Research Collections Program

Unfortunately, in contrast to the response by NSF to document the biodiversity of the planet by supporting taxonomic research and fieldwork, NSF's Biological Research Collections Program (BRC) has had a flat annual budget of ca. $6 million for over 10 years. This situation exists in spite of the fact that the success of the new taxonomic initiatives at NSF is resulting in the annual addition of very large numbers of specimens to natural history collections. BRC is the only federal program supporting natural history collections, and its budget is a fraction of the total amount needed to properly house and care for the irreplaceable specimens and databases. **Workshop participants strongly recommend that the annual budget of BRC be increased to $20 million.** A budget of this amount will stimulate the scientific community to seriously consider the long-term needs of the nation in terms of collection-oriented education and research and to begin to address the problems of maintaining these collections in perpetuity. The present budget of BRC is too small to stimulate this kind of national response.

In addition, workshop participants recommend that BRC consider making small awards to institutions with collections to enable retirees to continue their taxonomic studies. Often, a retiree is one of only a few individuals with the taxonomic expertise required to make accurate identifications or complete monographs on poorly known groups of species. With small amounts of funding, perhaps only a few thousand dollars, these individuals can continue to make large contributions to our understanding of biodiversity.

A 10-Year Vision for Taxonomy and Natural History Collections

The steps outlined above require a substantial infusion of funds that is only likely to come from the federal government. However, the benefits to science and society will quickly justify the costs. Information that is already in databases around the country can be networked within a year and, with adequate funding, LINNE will be fully functional within a decade.

With implementation of the steps outlined above to strengthen and improve the state of taxonomy and natural history collections, significant progress in answering the following major research questions will be realized within the next decade:

1. What are the characteristics of biological diversity on Earth?

- **How many species are there?**
- **How are species distributed on the planet, and why are they distributed as they are?**
- **How do species vary, and what historical and ecological factors are responsible for the variation?**
- **How do sets of species covary across the habitats of the world and how do such species sets respond to environmental perturbations?**

2. What is the history of life on Earth?

- **How are species interrelated genetically?**
- **How has biological diversification taken place through space and time?**
- **What environmental factors lead to speciation, dispersal, and extinction?**

These research questions overlap the six environmental challenges identified for NEON [National Ecological Observatory Network] by the National Research Council and for which "a NEON-like national network of infrastructure would be essential for their solution" (National Research Council, 2004).

1. Biodiversity, species composition, and ecosystem functioning.
2. Ecological aspects of biogeochemical cycles.
3. Ecological implications of climate change.
4. Ecology and evolution of infectious diseases.
5. Invasive species.
6. Land use and habitat alteration.

Effectively addressing these environmental challenges requires accurate species identification and long-term information on the spatial and temporal distributions of organisms. Such information is generated only through taxonomic and phylogenetic research, and from natural history collection databases. However, because natural history collections are not managed as a coordinated national resource, this information now is only partially available and difficult to obtain. **In the opinion of workshop participants, LINNE is required for the success of NEON. If organisms cannot be identified correctly, all subsequent research is suspect.**

Important societal benefits that accrue from taxonomic research and natural history collections and that will be facilitated by LINNE include the following. Several fall into the category of improved bioforecasting; i.e., LINNE will enhance our ability to predict which organisms might be used by terrorists or that pose a significant threat to agriculture. LINNE also will improve our ability to forecast the impacts of climate change or extinction of particular species on natural or agricultural ecosystems.

1. Education: Source materials for classroom instruction and outreach programs, including images and published information, will become readily available - principally in electronic form. These materials will in turn enhance/restore organism-based instruction as well as offer new pedagogic opportunities such as the ability of students to readily test hypotheses with large sets of collection data.

2. Natural resource management: Improved information on biodiversity will enhance the ability of conservationists and resource managers to identify areas of high species diversity, high endemism, and exploitable resources, and improve efforts at protecting and managing natural resources.

3. Biosecurity: A wide array of species could be used to disrupt the economy and health systems of the United States, and the identification of organisms used, or having a potential use, by terrorists can be difficult. Species identification requires taxonomic expertise and information on diagnostic traits and geographic distributions of related

organisms. This information is stored in biological collections, although it presently cannot be obtained in a quick or efficient manner. Responses to possible bioterrorism threats must be swift. LINNE will cut the time to access data from years to minutes or hours. Seldom has it been possible to have such a profound and positive influence on the accessibility of a scientific resource database that is vital to the nation's security.

4. Our natural heritage: Natural history collections contain a unique and irreplaceable record of the natural and cultural history of our nation. Many of the specimens and ancillary data in collections were obtained prior to the major modifications of the landscape that have characterized the development of the United States and are irreplaceable. Indeed, the collections are the fundamental database on the changing landscapes and patterns of species distributions of the nation. It is important that this record be preserved in perpetuity.

5. Invasive species: Preventing invasions by noxious species and predicting the impacts of those already in the U.S. require accurate identifications of specimens and information on the natural distributions and ecological requirements of targeted species and with associated species that may interact, either positively or negatively, with the invading species. Invasive species can decrease land values dramatically in some cases and otherwise degrade the value of property. Interception of potential agricultural, forest or medical pest species at U.S. borders will be greatly facilitated by access to a distributed network of taxonomic resources

6. Agriculture and medicine. Management of pests of food, forest, fiber, and industrial crops; use of organisms as natural or biological control agents of pests; and management and control of vectors of diseases of humans, livestock, and plants are all critically dependent upon accurate and timely species identifications and the information contained in natural history collections.

7. Bioprospecting: Successful identification of new pharmaceuticals, foods, and other as yet-undiscovered uses for organisms requires taxonomic and phylogenetic research, and distributional information from natural history collections. Only natural history collections permit the correct identification and an understanding of the distribution of new species, any of which could provide an important new genetic or economic resource to humanity.

8. Forensic science: Forensic science is based on protocols that require accurate identifications of organisms and distributional information from natural history collections.

9. History of science: Early and modern explorers, from Lewis and Clark to current PIs of NSF grants, as well as molecular phylogeneticists and other scientists, deposit voucher specimens in natural history collections. These specimens document the paths and objectives of the explorers and scientists over the centuries and provide a unique and irreplaceable source of historical data.

Suarez and Tsutsui (2004) provide specific examples of the value of natural history collections to public health and safety, and to environmental change and challenges.

Implementation of Workshop Recommendations

Small groups of workshop participants and possibly other collection-oriented biologists will meet as needed to develop plans for the organization and implementation of LINNE. Objectives of participants at these meetings will be to oversee:

1. Production of a **full-color document** outlining the recommendations of the workshops and explaining the importance of taxonomy and natural history collections to science and society. The document will be distributed to appropriate scientists, administrators, policy makers, and other interested individuals.

2. Organizing a **steering committee** to serve as the spokesgroup for the systematic and natural history collections community and to carry the recommendations of the workshop forward to/for NSF. This committee will modify and continue to develop plans for the organization and management of LINNE.

3. Identification or creation of an **umbrella organization** to work in concert with the steering committee to provide a unified voice for taxonomy and natural history collections, and to emphasize the connection of taxonomy and collections to education, scientific research, and environmental challenges.

4. Organize additional **workshops** as needed to examine the governance, users, and technical aspects of LINNE.

All follow-up activities related to this workshop will be coordinated with those of the workshop for the "Development of a National Systematics Infrastructure: A Virtual Instrument for the 21st Century," held at the New York Botanical Garden on 11-13 December 2003.

Summary

Workshop participants recommend that natural history collections in the United States be managed as components of one large electronically interconnected network of biological observatories (LINNE). Only when organized as a network, with nodes in every state in the union, can these unique sources of scientific data be used to their fullest potential to meet scientific and societal goals of regional, national, and international significance.

Although the basic infrastructure for LINNE is in place in the form of natural history collections in universities and museums, funds are needed to expand and modernize collection facilities, update specimen identifications, and expand the electronic availability of collection databases. New investment is required in personnel, collections infrastructure, and a new informatics network. Information that is already in databases around the country can be networked within a year and, with adequate funding, LINNE will be fully functional within a decade.

Workshop participants also recommend that recent initiatives at NSF designed to enhance our taxonomic expertise and our knowledge of biodiversity (PEET, PBI, RevSys and AToL) achieve permanent status at NSF. Given the urgency of discovering and describing our disappearing biodiversity, these initiatives should be expanded to the fullest extent possible. Workshop participants also recommend that the annual budget of BRC be increased to $20 million and adjusted as appropriate in future years.

With the implementation of these recommendations, significant progress will be realized within the next decade in answering major research questions, including:

1. What are the characteristics of biological diversity on Earth?
   - How many species are there?
   - How are species distributed on the planet, and why are they distributed as they are?
   - How do species vary, and what historical and ecological factors are responsible for the variation?
   - How do sets of species covary across the habitats of the world and how do such species sets respond to environmental perturbations?

2. What is the history of life on Earth?
   - How are species interrelated genetically?
   - How has biological diversification taken place through space and time?
   - What environmental factors lead to speciation, dispersal, and extinction?

LINNE also will greatly facilitate progress on meeting the six environmental challenges identified by the National Research Council for NEON:

1. Biodiversity, species composition, and ecosystem functioning.
2. Ecological aspects of biogeochemical cycle.
3. Ecological implications of climate change.
4. Ecology and evolution of infectious diseases.
5. Invasive species.
6. Land use and habitat alteration.

Important societal benefits will accrue from taxonomic research and natural history collections, and will be facilitated by LINNE. These include benefits related to:

1. Education
2. Natural resource management
3. Biosecurity
4. Our natural heritage
5. Invasive species
6. Bioprospecting
7. Forensic science
8. History of science

Small groups of workshop participants and other collection-oriented biologists will meet as necessary to develop plans for the organization and implementation of LINNE. Objectives of participants at these meetings will be to oversee the production of a full-color document outlining the recommendations of the workshop and explaining the importance of taxonomy and natural history collections to science and society, to organize additional workshops as needed, and to establish a steering committee and identify an umbrella organization to serve as spokesgroups for the systematics/natural history collections community and to carry the recommendations of the workshop forward to/for NSF.

References Cited

Black, C. C. 1984. Dilemma for campus museums: Open door or ivory tower? Museum Studies Journal 1:20-23

Claridge, M. F. 1995. Introducing Systematics Agenda 2000. Biodiversity and Conservation 4:451-454.

Gropp, R. E. 2003. Are university natural science collections going extinct? Bioscience 53:550.

Lipscomb, D., N. Platnick and Q. Wheeler. 2003. The intellectual content of taxonomy: A comment on DNA taxonomy. Trends in Ecology & Evolution 18(2):65-66.

National Research Council. 2004. NEON: Addressing the nation's environmental challenges. The National Academies Press, Washington, D.C. 108 pp.

National Science Board. 1989. Loss of biological diversity: A global crisis requiring international solutions. Report NSB 89-171. National Science Foundation, Washington, D. C.

Rodman, J. E. and J. H. Cody. 2003. The taxonomic impediment overcome: NSF's partnerships for enhancing expertise in taxonomy (PEET) as a model. Systematic Biology 52:428-435.

Rose, C. L. and C.A. Hawks. 1995. A preventive conservation approach to the storage of collections. Pp. 1-20 in C.L. Rose, C. A. Hawks and H. H. Genoways (eds.). Storage of Natural History Collections: A Preventive Conservation Approach. Society for the Preservation of Natural History Collections, x + 448 pp.

Ronquist, F. and U. Gardenfors. 2003. Taxonomy and biodiversity inventories: Time to

deliver. Trends in Ecology & Evolution 18(6):269-270.
Suarez, A. V. and N. D. Tsutshi. 2004. The value of museum collections for research and society. Bioscience 54:66-74.
Sugden, A. M., B. R. Jasny, E. Culotta, and E. Pennisi. 2003. Charting the evolutionary history of life. Science 300:1691.
Systematics Agenda 2000. 1994. Charting the biosphere: A global initiative to discover, describe and classify the world's species. Technical report. American Society of Plant Taxonomy, Society of Systematic Biologists and the Willi Hennig Society, New York.
Tirrell, P. B. 2001. Strategic planning and action for success in a university museum of natural history. Pp. 105-120 in M. Kelly (ed.): Managing University Museums: Education and Skills. Organisation for Economic Co-operation and Development, Paris.
Wheeler, Q. D., P. H. Raven, and E. O. Wilson. 2004. Taxonomy: Impediment or expedient? Science 303:285.

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