REPORT OF THE SECOND WORKSHOP

ON THE

BIODIVERSITY OBSERVATION NETWORK

January 14 – 16, 1999

National Center for Ecological Analysis and Synthesis
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I. Introduction

Biological diversity is the nation's natural capital. It comprises our native plants, animals and microbes, their genetic diversity and their organization and functioning as populations, species, communities and ecosystems. Biodiversity and the healthy ecosystems that underpin it sustain our economy and way of life, providing the nation with "clean air, clean water, food, clothing, shelter, medicines, and aesthetic enjoyment" (PCAST, 1998).

A grand challenge for the 21st century is to understand the nation's biological diversity in all its complexity in order to use and preserve it in a sustainable fashion (Bloch et al., 1995; PCAST, 1998). This knowledge is critical to science and society—for maintaining the nation's natural resources, for growing its economy, for sustaining human health, and for improving the quality of human life. The need for this knowledge is urgent as the daily conversion of natural systems to human-managed systems accelerates the decline of biological diversity and its habitats, "disrupting natural ecological processes, and even changing climate patterns on a global scale" (PCAST, 1998).

To achieve this understanding, we recommend that the National Science Foundation establish a new national research program called the Biodiversity Observatory Network (BON). Our recommendation emerges from two workshops held September 10-11, 1998, at Blandy Experimental Farm, Virginia[1], and January 14-16, 1999, at the National Center for Ecological Analysis and Synthesis, Santa Barbara, California[2], each involving approximately 25 of the nation's systematists and ecologists.

The mission of BON will be to advance knowledge of the biological, physical and social determinants of biological diversity, its environmental consequences and its role in determining biocomplexity. We define the nature and scope of biodiversity to include taxonomic composition and phylogenetics, genomic traits, species interactions, ecosystem function, and landscape patterns that characterize life on earth. These elements will complement other NSF programs that support studies of evolutionary and ecological patterns and processes. The BON enterprise will require and foster partnerships and research networking across disciplines and directorates within NSF, among agencies and across many sectors of the scientific community.

Specifically, five components of biodiversity will require discovery and elucidation:

1. The composition of biodiversity—what are the species of plants, animals and microbes that constitute the nation's natural biological capital?
2. The patterns of biodiversity—what are the ecological and evolutionary patterns revealed by biodiversity through time and across space?

[1] http://www.vcrlter.virginia.edu/biodwrk98/BIOWRK98.htm
[2] http://www.vcrlter.Virginia.EDU/biodwrk99/

3. The processes of biodiversity—what are the ecological and evolutionary processes and mechanisms that govern biodiversity phenomena across space and through time?
4. The function of biodiversity—what are the relationships between biodiversity and the structure and functioning of ecosystems?
5. The human dimensions of biodiversity—what are the interactions between biodiversity and human social, cultural and economic dynamics?

BON will be a platform for the study of the nature and scope of biodiversity and the dynamics that underlie them. We recommend that BON encompass the following attributes:

- Biodiversity observatories—installations with appropriate facilities distributed widely across the United States at which researchers will discover, document, measure and analyze biological diversity and its spatial and temporal dynamics.
- A network that will provide a common operational and intellectual framework for integrating research across biodiversity observatories.
- A technological coordinating facility to provide research, integration, service and support in the areas of infrastructure, informatics, analytical approaches and research protocols.
- Opportunities and resources to promote cross-observatory biodiversity research.

II. Rationale for BON

BON will enable science and society to gain a deep understanding of biological diversity. A research network of biodiversity observatories of the scale and magnitude envisioned for BON is required to acquire and integrate knowledge of the history, nature and scope of biodiversity through time and across space, and to decipher the interplay among its physical, biological and social elements. Our rationale for recommending the establishment of BON entails fundamental intellectual and infrastructural advances.

A. Intellectual synthesis across disciplines

The integration of biodiversity disciplines—notably systematics, ecology, population biology— is fundamental if we are to understand biodiversity phenomena through time and across space. Each of these fields has, separately, discovered much knowledge about the composition and nature of biodiversity. Each has a separate community of scientists, institutions and structures devoted to these fields of study.

For example, systematists use biocollections in natural history museums to study the taxonomic composition and evolutionary patterns and processes governing the history of life on earth. Ecologists utilize field sites (e.g., NSF's network of LTER sites, field stations, marine labs, national parks) to decipher ecosystem structure and function across space through natural experiments. Historically and currently, the integration of knowledge across these domains has been haphazard.

The Biodiversity Observatory Network is a new kind of research program and platform that will unite systematics, ecology and other appropriate disciplines in discovering and advancing knowledge of biodiversity. Such a synergism, which BON will demand and foster, is cardinal if investigations into the complex nature and scope of biodiversity are to be tractable and if we are to gain understanding of the temporal and spatial patterns of biodiversity and its biological, physical and social consequences.

B. Infrastructural impact

The BON program will have a major impact on the infrastructure of science and education in the United States. First, BON will provide the platform for educating a new cadre of biodiversity scientists for the 21st century, ones trained across disciplinary domains—systematics, ecology, conservation biology, population genetics, informatics, environmental economics, geospatial sciences and so on. Within systematics, BON will help reverse the loss of taxonomic expertise from the nation's systematic community, especially expertise in poorly known or studied organisms.

Second, the BON program will result in substantial species discovery, especially in poorly sampled habitats, such as soils. In addition to their importance for understanding biodiversity, these discoveries may have potential benefits, such as taxa with pharmaceutical properties. Also, BON's species discovery and survey will act, effectively, as an early warning system of changes in biodiversity, many of which may have important consequences to human society and well-being. Examples of such early warning biodiversity observations include algal blooms, declining amphibian populations, emerging disease pathogens and vectors, invasive and pest species, genetically engineered taxa, and anthropogenic changes to the environment.

Third, the collaborations across disciplines fostered by BON will produce new, integrative research tools, data and information sets and protocols for the investigation of biodiversity phenomena. These new infrastructural resources will enable novel research opportunities within and beyond the BON community of scientists, students and educators.

Fourth, BON will establish and leverage a network of new and existing installations with the requisite long-term security and hence, continuity, to observe and study the nature, scope and temporal patterns of biodiversity.

Fifth, BON will provide novel opportunities to educate and inform the public about biodiversity. BON's informatics resources and its research and educational collaborators, such as museums, will enable public education and outreach concerning life in America and the biodiversity in its backyard.

Finally, BON will be an essential node and entry point in a global biodiversity network, such as the planned Global Biodiversity Information Facility (PCAST, 1998; http://www.oecd.org/dsti/sti/s_t/ms/index.htm). Other nodes would include the

International Biodiversity Observation Year, Species 2000, ITIS, ISEC and other US Government, NGO and university initiatives.

Other infrastructural impacts, particularly on the systematics community and its collection-based institutions and resources, involve possible impediments and opportunity. BON research will demand significant taxonomic expertise and a critical mass of taxonomists, which is currently lacking for some taxonomic groups and insufficient for many others. In addition, research at BON sites will require (a) systematists trained in specialized survey, inventory and collecting techniques, (b) biocollections institutions that can house the volume of voucher collections generated at observatories, and (c) biocollections support staff that can curate and manage the new collections and their associated data.

A related issue is how systematics research, which tends to be clade-based and therefore world-wide in scope, can best benefit from the site-based nature of the BON program, which will be limited, at least initially, to the United States. Also in that regard, many the nation's biocollections institutions are focussed on documenting biodiversity in species-rich and poorly known areas of the world, especially the tropics, rather than the United States.

Workshop participants agreed that these possible impediments may represent new opportunities in the BON enterprise for large-scale undergraduate and graduate training in systematics, for strategic growth of the nation's biocollections institutions, resources and community infrastructure, and for expanding systematics research. A third workshop for the systematics community will be convened in May, 1999 to discuss these issues and make additional recommendations.

III. Observatories

We envision a network of observatories, each comprising one or more installations linked by a common research theme. Theme-centered observatories will enhance our understanding of broad spatial patterns, long-term temporal dynamics, and the evolutionary and ecological mechanisms that underlie them. The advantages of such a network of observatories include:

1. Broad biogeographic and taxonomic representation to incorporate many of the important patterns and processes related to biodiversity.

2. Long-term maintenance and security of installations dedicated to biodiversity research.

3. An intellectual and electronic matrix that promotes productive collaborations among ecologists, systematists and other scientists.

A. Core Research Areas

To maximize the benefits of the network, researchers should target a suite of core research areas at each observatory. The core areas are focal points to integrate research and ensure synthetic understanding of biodiversity. We recommend that five core research areas should be investigated at each observatory.

1. **Assessment of biodiversity —** Survey of extant taxa and their systematics and phylogenetics based on new and existing collections of specimens, tissues and other appropriate materials. We recommend that biologically compelling suites of taxa (see below) be surveyed and inventoried concurrently. Assessment of taxonomic composition at observatories may require a phased implementation, which, cumulatively, will yield a much more comprehensive understanding of the biota than is currently available.

2. **Spatial Pattern of Biodiversity —** Analysis of the composition and structure of the biota to promote spatially explicit comparisons within and among installations based on biotic and abiotic variables. This biogeographic theme would include examination of biodiversity along latitudinal, altitudinal, and salient environmental gradients; between habitats; between disturbed and undisturbed areas; and ultimately include analyses at the largest of spatial scales, regions and entire continents.

3. **Temporal Dynamics of Biodiversity —** Analysis of changes in patterns of biodiversity over time by comparing baseline and historical (e.g., museum collections) information with repeated and long-term measures taken within and across observatories. This will allow an analysis of the trends in biodiversity over ecological and evolutionary time scales with respect to natural variation and anthropogenic causes.

4. **Mechanisms Generating Patterns of Biodiversity —** The layering and integration of evolutionary and ecological analyses of pattern and process will provide a robust understanding of the origin, maintenance, dynamics, and functional consequences of biodiversity.

5. **Social and Economic Dimensions —** Human activities impinge on and respond to aspects of biodiversity. Examples here include changes in land use patterns, watershed ecology for rural and urban areas, depletion or degradation of natural resources, ecosystem services that benefit humans, and the effects of biotic components, such as pathogens and their vectors, on humans and human populations.

B. Observatory Characteristics

In order to fulfill the BON mission, the network should reflect the biological and geographic diversity of the United States. The distribution of observatories should encompass the diversity of habitats and ecosystems as well as disturbed and undisturbed areas. As such, we recommend that each observatory have the following characteristics.

1. Each observatory must be
   - sufficiently large in area to allow resolution of questions concerning its biota, the spatial scaling of biodiversity and the ecological mechanisms that affect it.
   - managed and protected to ensure that long-term studies can be executed to understand the temporal dynamics of biodiversity.
   - associated with appropriate repositories (e.g., museums) for voucher specimens, tissues and other appropriate material to provide long-term continuity for the systematic documentation and description of biodiversity.

2. Observatories should be situated and dispersed in a manner to reflect or represent
   - broad-scale variation in the taxonomic composition of natural communities.
   - broad-scale gradients of temperature and precipitation.
   - variation in relevant geological and environmental characteristics.
   - unique or endangered biotas, or areas of diversification or radiation.
   - gradients of taxonomic complexity—for example, from relatively species poor to relatively species rich—to facilitate linking biodiversity to ecosystem function.

C. Minimum standard installation

The BON research mission requires that each installation in an observatory be equipped with minimum state-of-the-art tools and facilities, as follows:

1. Geo-referenced template at multiple scales as a spatial reference for measurements of biodiversity.

2. GPS, GIS, and geostatistical capabilities for identifying research sites, and for processing and analyzing data concerning biodiversity. Examples include data layers for topography, hydrology, soils and vegetation.

3. Climatic and biogeochemical instrumentation to provide appropriate resolution for spatial and temporal patterns of precipitation and temperature. Specifically, each observatory should be equipped to measure meteorological data and key ecosystem variables such as soil pH, C, N and productivity, or appropriate similar measures for aquatic or marine systems.

4. Informatics and communications capabilities to link personnel working at an observatory with each other, as well as with personnel associated with other observatories and the BON coordinating facility.

5. Appropriate field facilities (e.g., environmental, analytical, and computational laboratories; lodging quarters; vehicles).

6. Ability to collect and temporarily house taxonomic voucher specimens, tissues and other appropriate material and arrange for their eventual curation. Association with a museum or other archival repository is required.

7. Quantitative description (composition and distribution) of plants and possibly other core taxa.

D. Core Taxa

The issue of whether all observatories should regularly assess specified core taxa is critically important to comparative and comparable research within and among observatories. The benefits of such a standard protocol are clear. A number of taxa—for example, vascular plants—are the basis for many of the processes associated with biodiversity, and measures of their composition, occurrence and abundance would be fundamental to BON research. Information on the same taxa across many installations would be especially powerful for analyzing evolutionary and ecological patterns and processes of biodiversity across a broad geographic scale.

However, the problems with identifying and assessing core taxa are just as obvious. For example, the concept of common core taxa does not apply to observatories with dramatically different habitats, such as aquatic versus terrestrial ones. In addition, individual observatories may differ in the suites of taxa considered important by ecologists and systematists dedicated to investigating them.

One plausible solution to this conundrum is to develop a stratified sampling approach in which a common suite of core taxa are surveyed comprehensively to ensure sufficient comparability of research within and among observatories. These core taxa should be appropriate to the habitat (e.g., aquatic, marine, terrestrial) and should encompass producers, consumers and decomposers. Other taxa could be assessed in a less intensive fashion or as demanded by a specific research hypothesis.

We suggest, for example, that the suite of core taxa at a terrestrial installation might include:

- vascular plants and fungi
- mammals, birds, reptiles and amphibians
- butterflies, ants, scarab beetles and spiders
- mollusks
- nematodes, microbes or other appropriate soil biota.

Core taxa for an aquatic installation might include:

- algae and diatoms
- macroinvertebrates
- fish

E. Research at Observatories

The network of observatories should develop in a manner that promotes the "network" attribute from the very beginning, rather than waiting for an array of isolated installations to mature into a network. We recommend that the majority of initial observatories be composed of clusters of installations, with each observatory focused on a research theme. Research themes should encompass the pattern of biodiversity and their evolutionary and ecological dynamics.

For example, one observatory designed to investigate the biodiversity of lakes of different ages might include installations at six lakes dispersed across North America. The common research theme uniting the observatory and justifying the choice of installations would be the evolutionary history, systematics and patterns of biodiversity of particular organisms. Another observatory might be designed to investigate the effect of latitudinal and altitudinal gradients on the diversity of plants and other organisms, perhaps involving eight installations across these gradients. The research theme uniting a third observatory might be the systematics and ecology of taxa in soils that differed in ratios of carbon to nitrogen. These installations, dispersed in accordance with the research question, would sample an array of designated taxa.

There are clear advantages to initiating the Biodiversity Observatory Network as clusters of installations united by research themes to form observatories. First, it would ensure that installations and observatories will be networked at the onset of the BON program. Second, because these observatories would sample the same suite of core taxa, broad questions could be addressed along gradients of interest (such as geologic age, latitude, altitude, and C to N ratios, to cite previous examples). (Fig. 1).

Although clusters of installations might be used to initiate the observatory network, individual installations should be accommodated if they represent compelling ecological or systematic phenomena, or if they add sufficient research significance to an existing cluster. Also, once the network has matured, i.e., once several observatories (clusters of installations) have been established, the BON program should foster research that cuts across these installations and observatories to address novel sets of biodiversity questions. Indeed, we think that cross-observatory research is likely to provide the most exciting and innovative advances in knowledge in systematics and macroecological disciplines. Ultimately, the matrix of research within and across observatories will be BON's intellectual glue.

Biodiversity Observatory Network

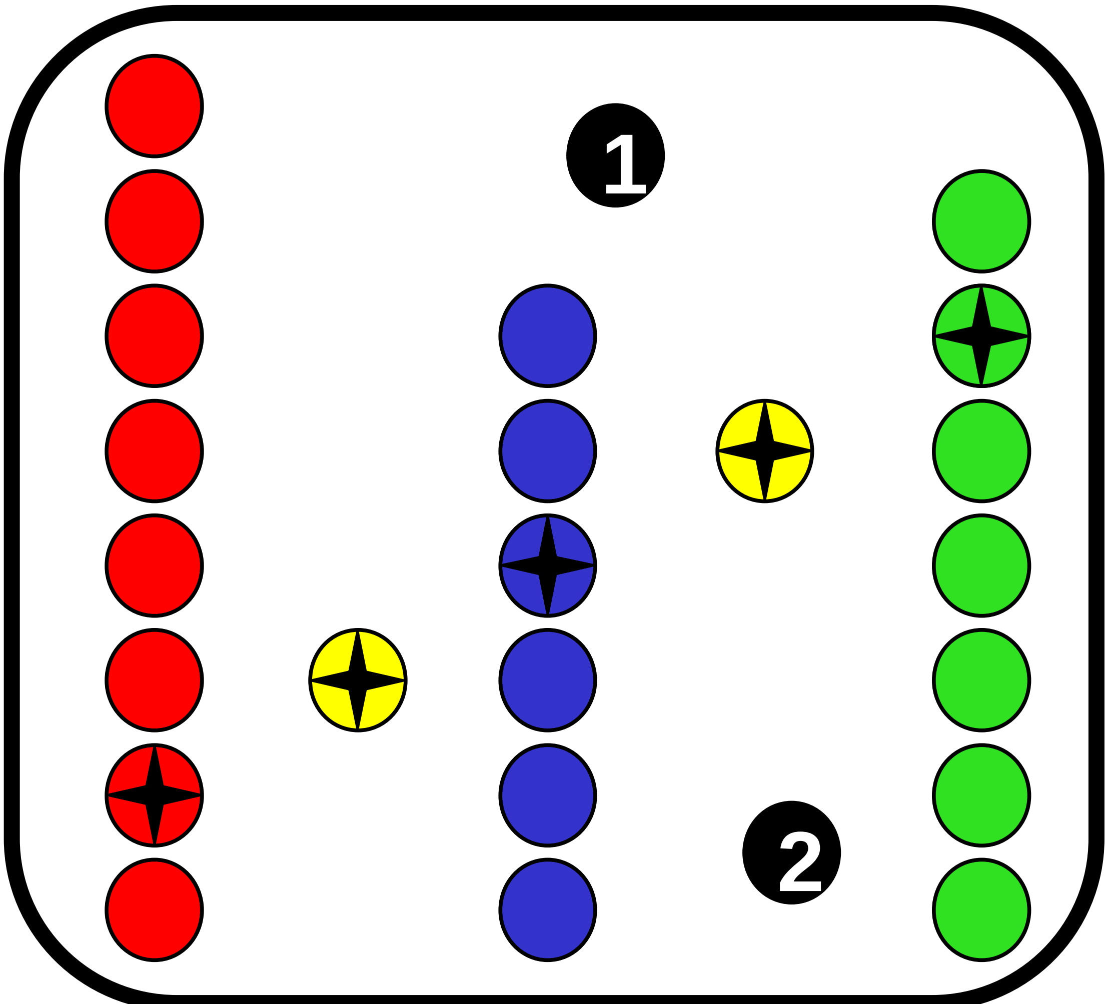

Figure 1—*Illustrative scenario for the ontogeny of BON. Initially the network might comprise three observatories, each based on distinctive themes, for example lake gradients (red circles), elevational gradients (blue circles), and soil biota (green circles). Subsequent installations would be added to the network to compliment current observatories and expand the breadth of research. A set of two new installations (yellow circles) might be added to complete a geographic gradient that examines biodiversity at aquatic-terrestrial interfaces (embedded stars), representing a new observatory. Alternatively, two new observatories, each including a single installation (black circles), could be added to the BON, with one addressing biodiversity of plants and their associated herbivores (embedded 1) from a coevolutionary perspective, and the other examining the effect of anthropogenic activity on stream diversity and ecosystem functioning (embedded 2). Cross-installation research supported by BON would further intellectually integrate the network and could involve many installations by examining broad questions such as the relationship between phylogenetic relatedness and richness of local ensembles of chrysomelid beetles, or scale-dependence in the relationship of plant species density and net primary productivity.*

F. Scope and budget

A critical number of installations is required to understand the complexity of biodiversity across the United States. We envision the network of observatories addressing no fewer than 10 major research themes, with each observatory comprising an average of perhaps six installations for a total of 60 installations.

We estimate the following budgetary needs for BON:

- ***Set-up and initial survey***: Approximately $1M per installation will be required for its establishment and to conduct the initial taxonomic and ecological survey. Proposals to establish observatories should also include the funds required for their administration. Total budget to establish 60 installations and perform initial surveys is $60M.
- ***Repeated measures***: Approximately $500K every two years will be required to conduct repeated biotic and abiotic measures at each installation.
- ***Research***: Approximately $750K to $2M per year will be required for research within observatories over and above the initial survey at each installation. At least $2M per year will be required to conduct research across observatories—and more when BON will number 60 installations. These estimates are based on the cost of research at and across LTER sites. The total research budget for within and cross-observatory research is estimated at $50M per year.

IV. BON Facility for Infrastructure, Research and Education (The BON Facility)

A. Overview

We envision the BON facility to be a vibrant, leading edge facility to support BON's infrastructural, research and educational needs. The facility's mission would be to complement and extend observatory research by performing a vital subset of BON functions—those that require a single point of focus, clearly benefit from the economy of centralization, or extend the capabilities and impact of the network beyond the capacities of individual observatories. These activities would include:

- Facilitating integration and analysis of observatory research data
- Providing knowledge networking and technical interoperability with the geospatial, genomics and other research and resource management communities
- Providing research informatics services
- Facilitating high-speed networking opportunities for BON
- Providing programmatic outreach, some forms of training, and technical infrastructure research and deployment.

B. Scope

The BON facility should provide coordination activities for the network. It will facilitate data analysis and synthesis, collaborative cross-observatory workgroups, and the production and scheduling of cross-observatory deliverables. The facility will archive observatory data and provide technical support for their integration with tools, data and research programs in other knowledge domains, such as the broader earth systems sciences. We envision that the facility will be the intellectual portal to the BON, providing a point of entry for external users, collaborators and agencies.

Although the core mission of the BON facility should be to provide research support for the observatories and a technical hub for network activities, its impact should extend far beyond the installations and their research programs. Integration with other research, natural resource management, and international communities should be a high priority in an ongoing and aggressive program of leveraging BON activities. BON's core observational data should be openly accessible; the technologies developed by the BON facility should be distributed to and deployable by researchers and entities outside of BON.

C. Infrastructure research and deployment.

The BON facility should provide both a "push" and a "pull" for the observatories in the development and deployment of new types of research infrastructure. Technical leadership with support services to meet the basic needs of observatories (the "push") complements leadership that comes from being on the leading edge of research infrastructure development. The "pull" of new technologies should be strategically focused to advance the effectiveness of core research at all of the observatories as well as to address opportunities for BON researchers for innovative research data integration and analysis. The "collaboration infrastructure" should emphasize activities for cross-installation and cross-observatory analyses, regionalization, and projection of BON findings to environmental questions on a national and international scale.

The BON facility's mission for knowledge management should be

- the development of a standards-based network data architecture, and
- the deployment of hardware and software tools that support research synthesis and the analysis of BON data, particularly with the objective of integrating BON data with information from other earth systems science communities to address new classes of research questions.

Functionally, the components of this mission comprise five classes: Description, acquisition, archive and retrieval, access, and communication.

Description. This component, the development of technical protocols, includes

- standards for data representation and abstraction to facilitate the network discovery of data resources and
- on-line integration of data within BON systems and with data from other earth systems science communities.

Infrastructural deliverables to the observatories would include:
- BON data and knowledge management guidelines
- best practices analyses
- metadata standards
- data verification and transformation tools, and most importantly
- a standing, collaborative, process for BON standards development and maintenance.

Interdisciplinary and inter-sector collaboration will be essential, given the amount of standards development currently underway in related geospatial, biological and natural resource management communities (e.g. FGDC, LTER, TDWG, ESA, NBII, NASA, EPA, W3C, OMG, NISO, ISO, CIMI, DC, LOC, ALA).

Acquisition. The BON facility will have two large data acquisition activities in addition to coordinating the management of biotic data that observatories will collect as part of BON's profile for core taxa.
- assembly and integration of data from existing biodiversity collections.
- production-level gene sequencing from observatory samples

The challenges in acquiring these data are large and critical, and are bottlenecks in the progress of research. Various organizational approaches are possible and optimizing a strategy for acquiring these data would itself constitute infrastructure research for the BON facility. For example, the BON facility, using existing national sequencing centers with excess capacity, could provide sequencing services for the observatories. But the cost-effectiveness of this approach would need to be evaluated against the research opportunities and costs that would be associated with a BON facility sequencing center.

For the acquisition of data from biological collections, the BON facility might coordinate contracts with a data entry service provider to automate data collection from U.S. specimens. Alternatively, it might prove profitable for the BON facility to coordinate or conduct research on the application of video technologies and robotics to handle large numbers of voucher specimens from the observatories.

Archive. Observatories should be responsible for the primary storage and management of their research data, but the BON facility should manage a long-term, secure archive of BON information resources. The archive should be managed in a proactive manner. It should take advantage of new storage technologies, evolving metadata access frameworks and high-speed networking. In so doing, it should provide clearinghouse functions for scientific users and serve as the BON data portal for external communities. Research underway at SDSC and elsewhere on data intensive computing and distributed object computation, represents exciting new directions for enabling research with large data archives. Self-identifying, self-describing and self-manipulating properties will turn biodiversity archives into components that are immediately accessible and active for data analysis, mining, visualization and other kinds of scientific discovery.

Access and retrieval. The BON facility would, with the observatories, coordinate the development of open-access policies for core survey data and implement a distributed computing retrieval architecture based on national and international protocols. Although technical advances in this area are rapid, likely protocols would include non-proprietary standards such as the NISO Z39.50 Search and Retrieval Protocol, Common Object Request Broker Architecture (CORBA) and the Internet Inter-ORB Protocol (IIOP).

Communications. The community's restricted network bandwidth has constrained the nature of the biodiversity inquiry and limited the kinds of questions that can be asked of biodiversity data sets. Merging and correlating specimen or long-term ecological records with remote sensing data or with large models of elevation from distributed sources has been impossible for individual researchers due to network bandwidth limitations. The gigabit vBNS and Abilene (I2) networks and their successors will enable distributed computing applications that will integrate terabyte remote sensing data archives, high performance visualization, modeling and integration of biodiversity data sets. The BON facility, working with observatory scientists, should be on the leading edge of high-performance network applications that take advantage of distributed data stores and computational and visualization servers.

D. Timing

The BON facility's informatics activities should occur prior to the establishment of observatories. At least a year before the solicitation of BON observatory proposals, the facility should establish a data standards framework and derivative technical guidelines for the abstraction and representation of core BON data elements. These draft standards should address BON information management with the objective of creating a shared information space for collaborative research and comparisons across the observatories. There was workshop consensus, based on the LTER experience, that a standards framework for scientific information management would be a critical enabling technology for BON and, therefore, must be erected first, prior to an RFP for the observatories. Without such a standards framework planned and coordinated in advance, the incompatibilities arising from a heterogeneity of data semantics, information models and network interfaces among observatories will severely compromise BON's research, network, integration and outreach objectives.

E. Organization

Options for the BON facility's organization are centralized, distributed or a mixed model; in the latter two cases, appropriate functions would be distributed among a small number of observatories or collateral offices acting under the administrative and legal umbrella of a single facility. The workshop considered three organizational models:

1. the NSF PACI centers, with “top-down,” strong central coordination
2. the LTER Network Office, with relatively strong, “democratic” coordination of a more horizontally-distributed enterprise
3. NCEAS, strongly facilitating and supporting more “bottom-up” activities

Each of these models has its strengths and weaknesses. A consensus of the workshop was that the BON facility should combine the best organizational features of the three approaches. NCEAS, for example, has successfully pioneered meeting and coordination working group formats that could be applied to BON collaboration and research synthesis activities. The LTER enterprise has developed methodologies for collaboration in which individual LTER scientists and data managers test new technologies before they are proposed as core components of LTER network operation.

A second consensus was that a number of functions of the BON facility would benefit from some degree of centralization. For example, one office would be needed to act as a portal to other research communities and a focal point for BON activities. Also, some functions, such as development of software and data standards, require a critical mass of technical staff, for which a fully-distributed organization would create significant, unnecessary impediments. Other BON activities that would benefit from centralization include coordination of research, informatics, training, informal science education, and aspects of administration.

F. Coordination

The BON facility would foster the “intellectual” network of BON through scientific and technical workshops, study groups and other kinds of face-to-face meetings. It would schedule and organize meetings in support of specific research thrusts within and across observatories as well as facilitate communications with scientists and research enterprises external to the network. The BON facility would coordinate network development activities, initiate national and international partnerships, and attract and engage external communities in the activities of the network.

G. Outreach

External outreach should be a high-priority function of the BON facility. Core activities would include the promotion of BON activities among external networks, government and non-government agencies, and other sectors to position the network as a valued national resource for long-term biodiversity and environmental observation. A key role for the BON facility would be the development of partnerships with other NSF (and other agency) research networks, programmatic initiatives and research centers.

H. Training

Although most student training would be carried out at the observatories, the BON facility should have a training mission for postdoctoral, graduate and undergraduates that focuses on new and effective techniques for:

- research informatics
- biotic sampling, survey and analytical methodologies
- long-term management of installations, and
- collaboration technologies and techniques.

REU and IGERT programs would be an excellent collateral activity of the BON facility in collaboration with research and educational projects at the individual observatories. Internships at the facility for scientists from industry, academia, government and NGOs will bring fresh perspectives and the opportunity for training visiting scholars in long-term research methodologies.

I. Budget

The functions of the BON facility will grow concomitantly with the size and complexity of the network; its full implementation will require an operating budget of $5 M to $10 M per year as recommended by the recent Presidential Information Technology Advisory Committee report (http://www.ccic.gov/ac/).

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