BLANDY EXPERIMENTAL FARM

UNIVERSITY OF VIRGINIA

Final Report: BIODIVERSITY MONITORING WORKSHOP

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A NATIONAL BIODIVERSITY OBSERVATORY NETWORK

Recommendations and Rationale

Biodiversity is the outcome of interactions between the phylogenetic history of life on earth and ecological processes.. As such, biodiversity is the sum of life on earth and includes genetic, species and functional diversity. The status and trends in biodiversity reflect the health of the ecosystems that support and enrich human life. Hence, it has been widely recommended (see the PCAST report, "Teaming with Life: Investing in Science to Understand and Use America's Living Capital; Systematics Agenda 2000: "Charting the Biosphere"; and the Ecological Society of America's "The Sustainable Biosphere Initiative") that we understand the processes and dynamics underlying biodiversity, particularly within the context of environmental variation and anthropogenic change. There are crucial questions regarding biodiversity that are not tractable without a better understanding its temporal and spatial patterns.

Therefore, we recommend establishment of a Biodiversity Observatory Network (BON) consisting of multiple biodiversity observatories with minimum standard installations, a funding program for biodiversity research at the observatories, and a Biodiversity Technology and Analysis Support Center (BTASC). The network should include up to 50 sites where extensive, multidisciplinary, biodiversity studies would be conducted. These would be supported by the BTASC, which would perform research on and provide the infrastructure for the technological, analytical and informatics tools required for biodiversity research. This network will allow the investigation of questions such as:

1) What are the systematic (taxonomy, phylogenetic) features of biodiversity?
2) What are the temporal and spatial patterns of biodiversity?
3) What is the relationship between biodiversity and ecosystem function?
4) How are the systematic, genetic and functional components of biodiversity related?
5) How do evolutionary processes generate observed patterns of biodiversity ?

We feel that NSF is poised to lead such an effort, as evidenced by the success of the LTER network and other long-term research programs (e.g., LTREB), as well as its programmatic interest in supporting research on systematics.

The Biodiversity Observatory Network should consist of three elements – the observatories themselves, a program to support research across the network, and a center to coordinate the network, conduct research and training, and provide technical services.

Observatories

We envision a network of observatories that serve as a platform for study of biodiversity and the dynamics that underlie it. In order to capture the nature and scope of the complex pattern of extant biodiversity, and to understand how these might change over time, we recommend a network of widely distributed sites, throughout a range of different habitats and ecosystems, and in disturbed and undisturbed areas

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 evolution, systematics, biotic surveys and inventories, and ecology.

I. The Core Areas to be investigated at each observatory include:

1. Taxonomic Inventory - Survey of extant taxa and their systematics. We recommend that biologically compelling suites of taxa be surveyed and inventoried concurrently. This would yield a phased implementation and eventually a more comprehensive understanding of the biota than is currently available.

2. Spatial Pattern of Biodiversity – Analysis of the composition and structure of the biota within observatories will promote inter-site comparisons. These would include examination of biodiversity along latitudinal and altitudinal gradients, between-habitats, between disturbed and undisturbed sites, and ultimately to analyses at the largest of spatial scales, regions and whole continents.

3. Temporal Dynamics of Biodiversity – Changes in patterns of biodiversity over time will be analyzed by comparing baseline information with repeated measures taken over the long-term within- and among-observatories. This will allow an analysis of the trends in biodiversity over various temporal scales, and relative to both natural variation and anthropogenic causes.

4. Mechanisms Generating Biodiversity Patterns – The observatories would provide a platform for the study of evolutionary processes and patterns that contribute to dynamic patterns of biodiversity. Concurrent study of species interactions and how they vary depending on abiotic processes should be one focus. The opportunity to integrate evolutionary and ecological analyses of pattern and process will provide a unique and robust understanding of the origin, maintenance, and functioning of biodiversity.

II. Minimum Standard Installations for Each Observatory – To accomplish this research, each observatory will require a minimum installation of state-of-the-art tools and facilities.

- Geo-referenced grid at multiple scales as a template for biodiversity measurements
- GPS and GIS capabilities
- Climatic instrumentation

- Informatics and communications capabilities
- Appropriate field facilities – (e.g., laboratories, lodging)
- Ability to collect and temporarily house voucher specimens, and arrange for their eventual curation (association with a museum might be required)
- Quantitative description (composition and distribution) of plants and possibly other core taxa

III. Scope – The complex of research questions will be determined by the number of observatories in the network. We estimate that at least 50 observatories will ultimately be required, but these could be added incrementally over the first few years of the program (e.g., 10/year for 5 years). It is critical that the implementation of the network include sufficient funds to support the minimum standard installation, research on the core areas, and cross-site synthesis.

Many other components of the research infrastructure will be needed for the Observatory Network, and will be provided by the BTASC.

Research

I. Core Areas for Research

Research proposals for the creation of a biodiversity observatory should focus on the description of biodiversity, and an understanding the phylogenetic and ecological dynamics influencing it, both within and among observatories. Research must contain a fundamental taxonomic component, because clarifying taxonomy will be the first step in biodiversity assessment for most taxa. A variety of research goals can be accommodated within this design, including estimation of existing biodiversity, its spatial scaling, changes over time, its phylogenetic basis, and more synthetic analyses using pooled data generated over multiple observatories and comparable sites.

Biodiversity observatories and associated data will be available to all researchers. If sampling is to be conducted, information must be collected in a hierarchical design that accommodates analyses within and between different spatial and temporal scale. Research project designs should include the sampling of multiple taxa at multiple observatories in order to meet the principal goal of the BON to be both inclusive and expansive. Many taxonomic groups will be surveyed at each observatory, hence proposals that facilitate analysis of patterns and relationships among and between taxonomic groups and at different spatial scales should be encouraged.

II. Minimum Standard Installation

Data collection protocols should include metadata standards and recording, proper archiving of vouchers, and georeferenced sampling. Collection of DNA or other material useful in genetic and phylogenetic analysis is essential. Plans for data management and presentation must be developed as part of the research protocol. Sampling methods within a taxonomic group need to lead to comparability (unbiased estimation) of biodiversity among observatories and through time. While individual researchers may focus on particular taxonomic groups of organisms, and on certain metrics of biodiversity (e.g., genetics, ecosystem function), data collection that includes a suite of ancillary, more peripheral measurements on non-target taxa or processes may be required.

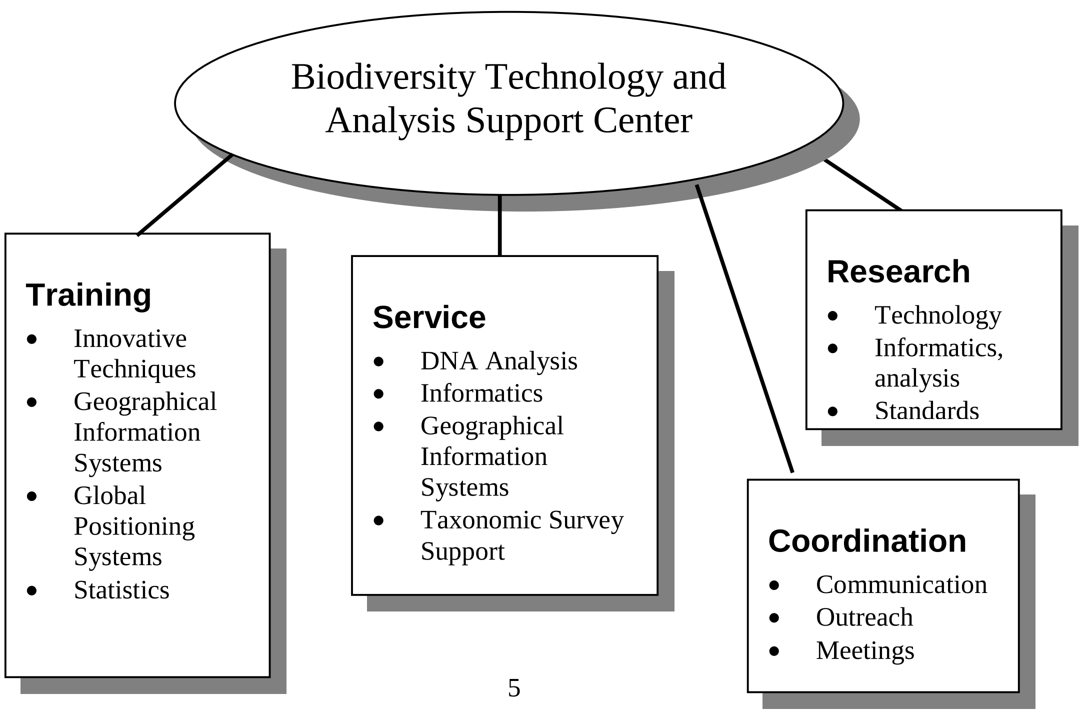
III. Scope

Grants should be up to 5 years in duration to allow sufficient time to both develop an initial evaluation of biodiversity and, where appropriate, to provide an estimate of temporal variation, recognizing that fundamental changes often occur over longer time scales than the five year renewable funding cycle. Research should allow for the assessment of biodiversity in a broad range of taxa across observatories, while encouraging research into the relationship between biodiversity and spatial scale within observatories.

Biodiversity Technology and Analysis Support Center

The Center will provide research, training, and service for the Biodiversity Observatory Network by coordinating infrastructure and facilitating research on emerging technologies and analytical approaches relevant to the study of biodiversity. Services will include those that are most efficiently provided centrally in support of the individual observatories and the scientists that use them. These include research and development on technical problems, analysis, informatics, and innovative training activities.

The Center, in collaboration with observatory scientists, will develop and maintain the information standards needed to generate comparable data sets among sites, based on shared schemas and ontologies. The center will model, engineer and distribute software tools for the acquisition and description of data sets in a metadata-driven computing paradigm in ways that both support the needs of researchers at observatories and the need to integrate them with the larger scientific community. Integration of geospatial data concerning GPS, GIS, and database technologies coupled with high-performance networking and distributed computing architectures will provide the core infrastructure for state-of-the-art analyses using scientific visualization tools. The Center will play a key role in establishing computing interoperability among observatories and with LTER, NCEAS, museum, library and geospatial data communities.



The Center will provide taxonomic survey support for the observatories to enable investigators to concentrate on species identifications, systematics, data analyses and related tasks. This taxonomic support could include, but is not limited to, sorting of taxa, generating metadata associated with the taxa, preservation of specimens, and preparation of material for molecular analyses.

A key focus of the Center will be the biodiversity and technology laboratory, with facilities and scientists for molecular analyses. Developments in biotechnology have accelerated research in biodiversity in organisms as diverse as vertebrates to microbes, and thus DNA sequencing technology is a high priority for systematics. The laboratory will enable cutting edge systematics and ecological analyses for individual investigators and teams working in the network.

Network activities will involve large multi-year data sets from constituent observatories. Consequently, the Center will provide support in areas of quantitative analysis (e.g., training of graduate students and observatory personnel), in GIS, geostatistical analysis, and meta-analysis, as well as research and development in these areas.

It is expected that many of the new technologies and analyses required for the complex study of biodiversity will require original research. Thus, the Center will be a focus for research in technology (equipment, methods), analysis (statistical, modeling), taxonomy and systematics (survey methods, phylogeny), and informatics (metadata, distributed access to data).

Training for graduate students and postdoctoral associates will be a major feature of network activities. The Center will provide innovative training opportunities on topics of common interest to observatories, to ensure comparability of results from different sites and to make expertise available to the wider scientific community. Areas likely to feature prominently in such training include systematics of poorly known taxa, molecular analysis and DNA technology, informatics, and quantitative analysis.

The Center will provide coordination for the network by facilitating communications between researchers and observatories in the form of periodic newsletters, electronic communication groups (e.g., electronic mail, chat, teleconferencing), maintenance of personnel and publication lists and specialized WWW pages. The center will serve as the coordinator for "All Observatories Meetings" at which network researchers will communicate research results and provide innovative training in rapidly evolving techniques that are critical to systematics and ecological research as they relate to the study of biodiversity. The Center also will provide a primary interface between the scientific community at large, other agencies interested in biodiversity research, and the network. Outreach activities will also include preparation of materials and WWW pages suitable for students (K-12, undergraduate) containing network results.

We recommend an additional workshop focusing on the nature of the Center and its relationship to the other elements of the Network. This should include considerations of the Center infrastructure as well as its relation to the network. Questions to be addressed: Does the Center occupy a single geographic location or should it be dispersed at different locations according to functional considerations? Is it supported by a single institution or a consortium of universities and museums? What are the priorities in equipment and staffing? What about estimates of cost? And: What are the possible phasing plans?

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