GROUP ON EARTH OBSERVATIONS

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GEO BON - Implementation Overview

Document 7

As accepted at GEO-V as a work in progress

GEO-V – 19-20 November 2008 **Document 7**

The GEO Biodiversity Observation Network

Implementation Overview: Early products and a vision for building the network

(As accepted at GEO-V as a work in progress)

EXECUTIVE SUMMARY

A worldwide Group on Earth Observations Biodiversity Observation Network (GEO BON) would link and thereby leverage efforts of countries, international organisations, and individuals to collect, manage, share and analyse observations of the status and trends of the world's biodiversity. It will contribute to improved natural resource management on the ground and also serve the eight other Group on Earth Observations (GEO) Societal Benefit Areas: Water, Health, Disasters, Climate, Weather, Energy, Ecosystems and Agriculture, because each affects or is affected by biodiversity.

The motivation for GEO BON lies in the critically important needs for biodiversity information at multiple scales, from local to global. GEO BON will largely arise from contributing systems that already have primary responsibility for biodiversity observations at global, national and sub-national levels. One of the central, and most crucial, activities for GEO BON will be to engage with various holders of biodiversity data, building on the work of the Global Biodiversity Information Facility (GBIF) and others, to bring a variety of analytical tools and models to the interpretation and use of existing biodiversity observations. An iterative consultation and information building process will be essential, and it will be imperative to draw upon the experience of other global efforts.

GEO BON will both benefit from and contribute to the Global Earth Observation System of Systems (GEOSS) based on the resources and experience of GEO BON members and partners. Potential GEO BON participants are GEO member institutions, non-governmental organisations, data providers and aggregators, tool developers and operators, and other types of practitioners with an interest in biodiversity observations and their applications for conservation and improved natural resource management.

One of the first steps in the implementation of GEO BON will be the early integration of some useful products. These products are examples of the types of analyses GEO BON will generate and include:

- aligned maps of ecosystem extent, biome occurrence, and species distribution data,
- an overlay of species occurrence and population trend data on remotely sensed data to ascertain drivers of population change,
- a comparison of spatial models of biodiversity distribution patterns that could be used to interpret remotely sensed land conditions, and
- a dynamic visualisation system that integrates geospatial and statistical biodiversity observations to develop composite indicators of biodiversity value and vulnerability with a focus on African protected areas.

The sheer diversity of data formats and standards in the biodiversity arena is a very real challenge to building a system of global biodiversity observation systems. The task will not be achieved overnight.

However, GEO BON can emerge through incremental efforts, building on existing initiatives that lead to organic growth as more and more players become partners.

The organisational structure and support levels for GEO BON are still to be determined, although it is clear that in order to coordinate activities and bring partners together, GEO BON will need some form of dedicated capacity. However, this capacity should be leveraged within the context of and in concert with GEO and associated activities. Thus, the nature of this capacity should be the subject of an ongoing conversation between GEO and GEO BON participants.

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1 INTRODUCTION

This Overview of plans for the implementation of a Group on Earth Observations Biodiversity Observation Network (GEO BON) is the result of an extensive, two-year long consultation among many components of the biodiversity community.

The compelling argument for establishing the Biodiversity Observation Network within the framework of the Group on Earth Observations (GEO) is its potential to interact with, support, and receive support from other GEO Global Earth Observation System of Systems (GEOSS) activities. It is clear that biodiversity observation and assessment cannot simply focus on biodiversity alone. The sectors represented by each of the other eight GEO Societal Benefit Areas (SBAs): Water, Health, Disasters, Climate, Weather, Energy, Ecosystems and Agriculture directly affect or are affected by the status of biodiversity. In addition, GEO is facilitating the development of components and services for GEOSS (including data sharing principles, inter-operability mechanisms, user requirements and interfaces, capacity building, and system architecture) that will significantly benefit GEO BON. The integration of GEO BON within GEO and its GEOSS should enable GEO BON to do a better job of:

- modelling biodiversity patterns, processes and services,
- detecting changes in the land surface and water cycle, and
- pointing to other needs of society that often must be traded off with biodiversity when we make decisions or consider the implications of scenarios.

DIVERSITAS, NASA and the U.S. Geological Survey (USGS) are taking the initial lead in forming a GEO Biodiversity Observation Network, in consultation with the GEO Secretariat and the biodiversity community. The development process has included soliciting both top-down and bottom-up conceptual input from the biodiversity community. Several workshops have taken place (for historical details, see section 1.2). The GEO BON Interim Steering Committee has drafted a *GEO BON Concept Document*, an important companion document to this Implementation Overview, which will be available at the GEO V Plenary.

1.1 The GEO BON Concept

In summary, the GEO BON idea is as follows.

● GEO BON is intended to facilitate linkages among countries, international organisations, and individuals, contributing to the collection, management, sharing, and analysis of observations on the status and trends of the world's biodiversity. As such, it will focus on observing and analyzing changes in biodiversity over time. In this context, it will also identify gaps in existing observation systems and promote mechanisms to fill them.

● Conceptually, biodiversity is viewed at three levels: genetic, species and ecosystem diversity, with terrestrial, freshwater, coastal, and open ocean components of biodiversity all being considered. GEO BON will encourage the collection of time-series observations on the presence, abundance and condition of elements of biodiversity at all of these levels.

● In addition, members of the GEO BON network will use the collated data to conduct analyses, such as change detection, trend analyses, forward projections, range interpolations, model-based estimations of the supply of ecosystem services, etc. These analyses will be important vehicles for information transfer to data users, stakeholders and the general public, and will support more detailed evaluations undertaken by biodiversity and ecosystem assessment bodies and serve to develop tools for analysis which can be used by the global community.

● Through an iterative consultation process between data providers and data users, GEO BON will be able to improve incrementally the relevance and timely delivery of information to various data users. All system standards and components will be evaluated with this in mind. Primary users of GEO BON

will likely be: countries (especially in relation to their obligations under biodiversity-related conventions) and their natural resource and biodiversity conservation agencies; international organisations and the biodiversity-relevant treaty bodies; non-governmental organisations (both national and international) in the fields of biodiversity protection and natural resources management; environmental and scientific research organisations both in and out of academia; the media; and the general public.

The unique niche and added value of GEO BON will be:

- Build upon, pull together and integrate existing major initiatives working with biodiversity data and information in order to derive higher-level "value-added" analytical products not available currently through the existing disparate activities.
- To provide a global, scientifically robust framework for observations on the detection of biodiversity change
- To build a global system of systems upon *in situ* and remote observation systems
- To coordinate aspects of data gathering and also the delivery of biodiversity change information
- To ensure long term continuity of data supply (i.e., operational observations)
- To provide, and be known for, a set of innovative and relevant products, based on the integration of key data sets (e.g., global maps of ecosystem service delivery, predicted areas of rapid degradation, key biodiversity sites facing rapid climate change)
- To be able to provide observations, models, assessments, and forecast information

1.2 History

The GEO 2007-2009 Work Plan calls for the development and implementation of a Biodiversity Observation Network (task BI-07-01) "that is spatially and topically prioritised, based on analysis of existing information, identifying unique or highly diverse ecosystems and those supporting migratory, endemic or globally threatened species, those whose biodiversity is of socio-economic importance, and which can support the 2010 CBD target".

DIVERSITAS, NASA, and GEO organised a workshop in October 2006 to identify user needs. In January 2008, a group of 18 authors assembled at the GEO Secretariat to write an initial draft of the *Concept Document* that would be the basis for discussion at a meeting of some 100 biodiversity specialists representing over 60 scientific and intergovernmental organisations in Potsdam, Germany, in April 2008. The participants discussed and amended the *Concept Document* and also instituted seven working groups whose task it has been to draft an Implementation Plan, of which this *Implementation Overview* is the first stage.

To inform the community at large about the plans for GEO BON, a policy forum paper was published in *Science*[1], as well as a chapter[2] in the GEO book *The Full Picture*. Also, the GEO BON initiative has been presented at various scientific meetings throughout the world and at the May 2008 Conference of Parties (COP9) of the Convention on Biological Diversity (CBD). At that meeting, the CBD COP adopted Decision IX/15 on the "Follow-up to the Millennium Ecosystem Assessment", paragraphs 10 and 11:

[1] Scholes RJ, Mace GM, Turner W, Geller GN, Jürgens N, Larigauderie A, Muchoney D, Walther BA, Mooney HA. 2008. Toward a global biodiversity observing system. Science 321:1044-1045

[2] Walther BA, Larigauderie A, Ash N, Geller GN, Jürgens N, Lane MA. 2007. Toward a global biodiversity observation network. Pp. 79-81 in: GEO - Group on Earth Observations (eds.). *The Full Picture*. Tudor Rose, Geneva, Switzerland

10. Notes the initiation of a Biodiversity Observation Network, established under the Group on Earth Observations, and the development of an implementation plan for the network, as part of the implementation of the Societal Benefit Area on Biodiversity of the Global Earth Observation System of Systems, and invites Parties, other Governments, relevant organizations, scientists and other relevant stakeholders to support this endeavour;

11. Requests the [CBD] Executive Secretary to continue collaborating with the Biodiversity Observation Network with a view to promoting coherent biodiversity observation with regard to data architecture, scales and standards, observatory network planning and strategic planning for its implementation.

1.3 Purpose of this document

This is not a detailed document intended to lay out a formalised plan for GEO BON over the next several years. Rather, it provides a high-level description of components and steps necessary for the initiation of GEO BON and for the coordination of a global system comprising existing and envisioned national and international systems for observing biodiversity. Potential GEO BON participants are the intended primary audience. These include GEO member institutions, non-governmental organisations, data providers and aggregators, tool developers and operators, and other types of practitioners with an interest in biodiversity observations and their applications.

The *GEO BON Concept Document* presents GEO BON's proposed structure and functions. This *Implementation Overview* describes the steps toward the initial development of a network of data providers, aggregators and users; some of the first GEO BON products; proposals for the coordinating mechanism; and a timeline. One of the first steps in the implementation of GEO BON is the quick development of some useful products. That is why potential "Early Products" are given special treatment – because such deliverables are one of the best ways to convey what GEO BON is all about.

Another purpose is to solicit feedback and provide a vehicle for engaging participants and potential participants in a dialogue to further refine development plans. This is particularly important because implementation of GEO BON is expected to be incremental, with planning being a continuous process. Consequently, this *Implementation Overview* should be seen as a working document. Together with the *Concept Document*, it is open to constructive discussion.

2 EARLY GEO BON ACTIVITIES AND PRODUCTS

2.1 Building the Data Provider Network

One of the central, challenges for GEO BON will be to engage various providers of biodiversity data. Biodiversity is not only complex in itself, but is observed by a varied group of organisations, institutions and individuals with widely differing agendas, budgets, constraints, and interests. In addition, there are the necessary global network infrastructures for data sharing such as the Global Biodiversity Information Facility (GBIF). Some data elements, particularly those of specimens and species have increasingly robust networks and standards which will provide a strong platform. Other elements, including, for example, phenology, ecosystem classifications, and animal movement have nascent networks and standards being developed, which GEO BON can assist and test for utility at different levels of analysis.

GEO BON will therefore need to allocate a portion of its resources toward improving interoperability among important observation classes, standards (existing, proposed, needed), tools, and observation data sets. GBIF's efforts to develop standards and infrastructure for sharing primary biodiversity data, including specimens, observation and multimedia data, are a useful model in this regard. A global network of biodiversity observation systems (GEO BON) will emerge through incremental efforts and organic growth as more and more players become partners in GEO BON.

An iterative consultation process between data holders and users of various kinds will be essential. It will be well to draw upon the experience of other global efforts.

2.1.1 Data sharing

GEO BON will feature both *in situ* and remote sensing observations of biodiversity at three levels of interest to biodiversity researchers and policymakers: genetic, species and ecosystems. In general, each type (*in situ* and remote sensing) and level of biological organisation has its own data and metadata standards, and their data are provided by different provider networks.

GEO BON will build upon the experiences of many partners and data providers, such as GBIF and GEOSS, thereby leveraging mechanisms already in place and adding to them those elements that allow the integration of biological *in situ* and remote sensing data.

- GBIF has worked with the Taxonomic Databases Working Group (Biodiversity Informatics Standards, or TDWG) to promote the adoption of standards for data and metadata that allow the seamless interchange of species- and specimen-level data from many providers with disparate databases and platforms. Ongoing interactions with (for example) the International Long Term Ecological Research Network (ILTER), the Inter-American Biodiversity Information Network's Ecosystems Thematic Network and the molecular informatics communities (GenBank and the Consortium for the Barcode of Life—CBOL) will extend GEO BON interoperability across all levels of biological organisation.
- At the same time, GEOSS is building upon, and adding value to, planned and existing Earth observation systems by connecting them to one another. This requires making these systems and components interoperable, so that the data and information they produce can be pooled and combined. GEOSS will become a system of systems by adopting appropriate standards for the interfaces through which the various GEOSS components exchange data and information.

2.1.2 Networking

An important role of GEO BON is to facilitate interactions among participants, so that synergies can emerge. GEO BON can be viewed as a dynamic system of systems for observing, recording and sharing data, but such a system must be constructed by people, who are variously employed by organisations, institutions, governments or perhaps themselves in the pursuit of their personal interests

(i.e., citizen scientists). People come together via social networks, and so there is need for a coordinating structure that functions to advise on integrating their separate actions to achieve goals that are decided upon in common—in this case, to build a global system that will facilitate biodiversity observation and decision-making around the world. This GEO BON system of systems must expand on existing initiatives. Both the social interpersonal network and the information-infrastructure based system (confusingly, such systems are also referred to as "networks") are components of the GEO BON.

2.1.3 Building capacity

GEO BON must have a capacity building strategy to allow growth, maintenance and balance for the network. This will be based on the principles articulated in the GEOSS 10-Year Implementation Plan Reference Document, and on ongoing capacity building activities extant among the participants. Thus, an initial survey of successful initiatives in member countries, followed by a more detailed survey of all existing initiatives, is needed to provide the necessary substrate for medium- and longer-term capacity enhancing actions.

The GEO BON capacity building strategy will be developed consultatively among the network participants, and incorporate actions to strengthen the capability of all GEO member countries, in particular developing countries, to use Earth observation data and products and to contribute observations and systems to GEO BON. It will also facilitate identification of solutions that enhance sustainability, thereby improving the contribution of science to society.

2.1.4 Citizen science

Some of the most vibrant and dynamic biodiversity observation systems are the citizen science networks and websites. Most biodiversity observation networks GBIF, the U.S. National Biological Information Infrastructure, the Australian CSIRO network, for example, are developing methods for incorporating citizen observations, of organisms as divergent as birds and mushrooms, into their data systems. GEO BON will be a more robust and encompassing network if it can help marshal citizen science and personal observations, assisting in the development of tools for data integration, quality assurance and control, and analysis. GEO BON will support citizen scientists' biodiversity related efforts through the development of a **CI**tizen **S**cience **B**iodiversity **O**bservation **N**etwork (CIS BON) led by one of the GEO BON participants (U.S. Environmental Protection Agency).

2.2 Early tools and products

Because GEO BON is to be a system of systems, some components have already been developed by countries, agencies, institutions or organisations. GEO BON Early Products will rapidly deliver new outputs of broad relevance to science and management while providing proof of concept for GEO BON (see section 2.2.2, Early Products). This should happen within approximately one year from the start of GEO BON activities.

2.2.1 Examples of existing data tools contributed by Network members

A variety of user-friendly tools are available to help GEO BON get started. These include but are not limited to:

- Rapid Land Cover Mapping Tool. A tool to develop land cover and ecosystem maps using visual methods.
- Global Data Toolset. An online polygon data entry tool to facilitate creation and validation of geospatial data such as protected areas, species distributions, or important bird areas.

- TerraLook. A system to provide recent and historical georeferenced jpg images, and desktop display and analysis software, to all types of users, regardless of their experience level.
- Andes Amazon Protected Areas Database. A system to help Protected Area managers view and share data for the Amazon region.
- The GBIF Data Portal. A single point of access to 147 million species occurrence data records provided (as of 1 Oct 2008) by 260 data holders worldwide.

2.2.2 Possible Early Products

Four items have been identified as potential GEO BON Early Products (see boxes on following pages). They can be developed collaboratively and with limited funding requirements, and are deliverable within the next year or so. These all align with the GEO BON vision of bringing together people and data from a variety of different sources to generate novel products that could not be achieved separately.

Early Product 1 Ecosystems

Rationale

Understanding ecosystem processes and their link to biodiversity is a fundamental aim of GEO BON. To do this, improvement is needed in the interpretation of ecosystem classification at the biodiversity level because this interpretation is integral to understanding how changing patterns of ecosystems are impacting biodiversity.

There are several terrestrial ecosystem maps available; however there is no knowledge of how they intersect with one another. This early GEO BON product would be an evaluation of the congruence and differences among these maps, a clarification of the information they can provide, and an improvement in how they are structured and modelled. This would in turn improve on ecosystem classification interpretive value.

Methods and data requirements

A number of ecosystem extent and biome maps will be aligned with each other and with species distribution data.

- ⇒ Global Ecosystems Map (GEOSS task EC-06-02)
- ⇒ Trends in global ecosystem extent products (WCMC, ESA)
- ⇒ Landcover maps (e.g. GLCC)
- ⇒ Species distribution maps (IUCN and others)
- ⇒ Species occurrence data (GBIF)
- ⇒ Biome type maps (WWF)
- ⇒ Biogeophysical land surface parameters such as Leaf Area Index (LAI), Net Primary Productivity (NPP) and albedo.

The team to undertake this work will be collaborative between land cover/remote observation and ground-based species/habitat specialists.

Potential Partner Organisations

UNEP-WCMC, ESA, USGS, GLCC, IUCN, GBIF, WWF, National Space Agencies and others

Prospective users

International and national organisations and conservation agencies, nation-states to monitor 2010 targets, CBD treaty bodies, etc.

Estimated additional cost of production

Approximately US$50k

Early Product 2 Populations and drivers

Rationale

One of the main methods for monitoring change in biodiversity is obtaining site-based measurements of population size at time intervals. But, to be predictive (and therefore offering the opportunity to be proactive) about population declines requires an understanding of the impact of drivers of change. There are ways to remotely sense the impact of these drivers on land cover (e.g. land use change, human appropriation of net primary production (HANPP), and Intergovernmental Panel on Climate Change projections) but these measures are not currently linked to site-based measures of population size.

Linking these two measures at the site level would enable an interpretation of the trends in population size, with respect to different known drivers of biodiversity change. Many of the data required are in place, but GEO-BON is needed to provide the forum through which these datasets can be brought together.

Methods and data requirements

Three species data types would be overlaid: GBIF-mediated occurrence data, population trend data sets from the Zoological Society of London, WWF, and Imperial College London, and distribution datasets (e.g. from IUCN) to gather sufficient population trend data. From this, measures of population change can be generated at the site level by population and by species. These measures would then be linked to change data for the same sites drawn from the remotely sensed datasets. The linked data could then be applied to questions such as:

- ⇒ Are areas of population declines and areas of rapid environmental change correlated or coincident?
- ⇒ Are particular drivers associated with population declines in particular species but not others?

Potential Partner Organisations

GBIF, Zoological Society of London, DIVERSITAS, WWF, Imperial College London, GLC 2000, and others.

Prospective users

Countries (for national level reporting), national and international conservation organisations and the biodiversity-relevant treaties.

Estimated additional cost of production

Approximately US$50k

Early Product 3 Biodiversity "Lens" approach

Rationale

The *GEO BON Concept Document* describes two forms of biodiversity monitoring:

⇒ Repeated *in situ* measurement of selected components of biodiversity at selected locations, to get time series for analyses; and

⇒ Modelling of patterns in the spatial distribution of biodiversity, using biotic/abiotic observations that are unconstrained by time or place, and then using these models as a "lens" to interpret remotely-sensed changes in ecosystem conditions.

The second approach is very amenable to producing rapid results because it can use existing data and modelling tools for an effective proof of concept without the need to wait for a time series of biodiversity observations to be collected. Important to the success of this approach, however, are observations from a wide set of participants. Fundamental biodiversity "observations" are very inclusive – covering many taxa that exist in many places, observed in a variety of ways. It can use the presence-only data found in the bulk of biological collections, and thereby demonstrate the synergies GEO BON has with other major initiatives that are working with such data, particularly GBIF.

The modelling approach adds value to biotic observations by integrating them with key environmental variables. Large scale integration of data on many species and environmental variables reveals underlying, common patterns. Thus, it provides a way to address biodiversity wholesale. GEO BON, in order to claim to be a true biodiversity monitoring network, needs ways to make inferences at this wholesale level in addition to repeated *in situ* monitoring.

Methods and data requirements

Modelling of spatial biodiversity distribution patterns, and then using these models as a "lens" to interpret remotely-sensed changes in ecosystem condition and other key drivers

The proposed outcome is a prototype global biodiversity model and tool that would demonstrate interpretive overlay with prototype time series of remotely-sensed land condition. This product will require GBIF-mediated data, additional environmental layers, and sources for remotely sensed landcover change information. These needs will create opportunities to link to GEO ecosystem classification, GLC2000, etc. One simple early product would be a lens model based on the "scaling" of an ecosystem classification using GBIF-mediated data.

Potential Partner Organisations

CSIRO, Australian Museum, biogenesis-DIVERSITAS, GBIF, Imperial College London, plus organizations providing land condition information; others

Prospective users

Users of such a product will likely be countries (especially in relation to their obligations under biodiversity-related conventions) and their natural resource and biodiversity conservation agencies, international organisations and the biodiversity-relevant treaty bodies, non-governmental organisations (both national and international) in the fields of biodiversity protection and natural resources management, and environmental and scientific research organisations both in and out of academia.

Estimated additional cost of production

Approximately US$50k

Early Product 4 Protected Areas

Rationale

A dynamic visualization system that integrates heterogeneous data (geospatial, statistical, observations) to develop composite indicators of biodiversity value and vulnerability is required to respond to the need for effective information to support policy planning and monitoring. In this system, a variety of sources would provide *in situ* data that document geographical extent, and these would be combined with routine and archived remotely sensed environmental observations such as fire occurrence and vegetation condition, climatic data, and measurements of agricultural and population/transport infrastructure expansion.

This visualization system would improve capacity to judge effectiveness of local protected areas, including local management decisions, as well as capacity to monitor pressures and threats to existing Protected Areas.

Methods and data requirements

An assessment of African protected areas (http://www-tem.jrc.it/PA/index.html) provides proof of concept. A consistent analysis of 741 protected areas is available online that compiles a huge amount of information linked with the most up-to-date databases. It also details the thematic analysis of the value of, and threats to, biodiversity in each park, and it compares the results by country and by ecoregion. An alert system, updated every ten days, detects unusual patterns in rainfall, fires, vegetation and seasonal water bodies in each protected area. These alerts are made available as GeoRSS feeds which users can subscribe to and map.

GBIF and UNEP-WCMC have begun development of a rich-internet-application to visualize information from protected areas together with specimen and occurrences data from GBIF and the World Database on Protected Areas. The application will be expanded to include richer data sources such as from taxonomical, geospatial, and literature references. In particular, through coordination with the African Protected Areas group at EC-JRC, the richness of visualized data will be increased.

Potential Partner Organisations

EC-JRC, UNEP-WCMC, GBIF, RSPB, BirdLife International, others

Prospective users

Africa Union Commission, National services in charge of wildlife management, Universities, NGOs, others

Estimated additional cost of production

Approximately US$25k

3 THE GEO BIODIVERSITY OBSERVATION NETWORK

GEO BON, as indicated in 2.1.2 above, would be a network of organisations, institutions and the people who work for them undertaking coordinated activities relevant to generating, from shared biodiversity data, information useful to society. Those data would be held and used by participants in the network, and are critically important to GEO BON goals.

3.1 Who are GEO BON participants?

The participants identified here (only a sample of the wide array of possibilities) are, with one or two notable exceptions, both providers and users of biodiversity information. Because biodiversity and its utilisation (conservation, research, human well being, education, trade, human and animal conflict, etc.) have so many aspects that impact positively or negatively on humans, there is a large potential audience for GEO BON.

Biodiversity related conventions (CITES, CBD, Ramsar, etc.) - The conventions need to assess and monitor the status of selected species, in order to deliver the most relevant information on biodiversity trends and evolution; to develop biodiversity indicators to facilitate that process; and to assess their effectiveness and communicate to their parties the good results, gaps and changes needed in their future development.

UN Organisations - The diversity of the support provided by GEO BON to the UN Organisations is important, since GEO BON will not provide only biodiversity data and assessment, but also reports on biodiversity components, including ecosystem goods and services (state of forest, agriculture and livestock, fisheries and aquaculture, soil biodiversity, etc.).

National and International Conservation Organisations - The benefit to conservation organisations will come from integration allowing them to do much more analysis, modeling, predictions, and scenarios work to better develop plans and priorities.

National Governments and Agencies - Because local organisations and governments have an interest in what happens in their region and/or country, local and national information and data will be part of the services provided by GEO BON.

Academic/Research Institutions - Many academic institutions perform and support biodiversity assessment and monitoring, provide data services and develop models and tools. Researchers especially would benefit from improved data availability and interoperability.

Private sector - Some private companies have an interest in biodiversity information and sustainable management when their business relies on its use and availability**.**

Sources of Genetic Information - GEO BON will provide a mechanism for researchers, conservationists and others to study genetic adaptations in relation to the geospatial framework within which they evolved, and enable discovery of environmental drivers of genetic change, adaptation, population decline, and other phenomena. The molecular informatics community has many sophisticated tools that may be adaptable to certain types of analyses of data types from the species or ecosystem levels of biological organisation**.**

DIVERSITAS - The international programme on biodiversity science of ICSU and UNESCO, is committed to providing strong scientific guidance to the development of GEO BON. Working through its international network of biodiversity scientists and in collaboration with many users and providers of data, DIVERSITAS will support the design of a system that can provide information at policy-relevant timescales and spatial scales on biodiversity components from genes and species to ecosystems.

GBIF - GBIF is an inter-governmental initiative mandated to facilitate development of a global biodiversity informatics infrastructure to enable free and open access to primary biodiversity data. GBIF has much to offer to GEO BON, including a growing global network of data holders, relevant information infrastructures, data exchange standards, and network-building experience. GEO BON has much to gain from the political agreements and social networking established by GBIF.

ILTER Network - The world's LTER sites are a rich resource of both aut- and synecological datasets already directly linked to geospatial data. Their datasets will serve as a valuable "ground-truthing" measure for remote sensing data and modelling efforts**.**

Space Agencies - Remotely sensed data are an important source of biological and environmental information, and are particularly valuable for biodiversity assessments when combined with ground observations, a process that often involves the use of computer models. Space agencies and organisations that utilise and process remotely sensed data have also expressed interest in participating in GEO BON, and some of these will help develop Early Products, as described in Section 2.2.2.

WCMC - The UNEP World Conservation Monitoring Centre is a collaboration to evaluate and highlight the many values of biodiversity and put biodiversity knowledge at the centre of decision-making through the synthesis, analysis and dissemination of global biodiversity knowledge, providing authoritative, strategic and timely information for conventions, countries, organisations and companies to use in the development and implementation of their policies and decisions. WCMC can both contribute to and benefit from GEO BON because of the data it holds and can share, and also because of its leadership role in the Conservation Commons.

3.1.1 How would participation be encouraged and developed?

As noted in section 1.2 (History), the promotion of GEO BON within the biodiversity community has already begun, through publications and scientific meetings. As the projects described in the "Early Products" section go forward, various organisations and individuals will be brought in through their work on those developments. However, these are not enough to secure the widespread participation in the network and development of the interoperable systems that will be needed to provide the greatest benefit to society.

Once GEO BON is accepted by GEO and its Steering Committee is established, it will be necessary to send directed invitations to as many entities as can be identified that hold or host biodiversity and/or remote sensing data of the types important to GEO BON. Early on the focus will likely be on the relatively small number of larger, global data providers, as this will allow a rapid increase in the volume of data available through GEO BON. Gradually, regional and local data providers will also be added.

Successful delivery of the "Early Products", with appropriate "branding and marketing" should attract additional participants because these products will make tangible the advantages to be gained from openly shared data that can be readily accessed, combined and analysed in a manner tailored to the needs of the user.

3.1.2 How would participation be coordinated?

GEO BON will be one of the systems of systems within GEOSS, and thereby will follow GEO guidelines.

The leadership of GEO BON would function as a coordinating mechanism. Like that in GEO, participation in GEO BON is voluntary and legally non-binding. No governing or committee body established within the GEO BON framework would have authority to direct participants. Rather, they would provide guidance and recommendations to participants and contributors, and serve as forums within which participants can express their ideas and come to consensus.

Though details remain to be worked out by the participants assembled in plenary, or committees appointed by them, it is envisioned that GEO BON would be led by a multi-stakeholder **Steering Committee,** which supports and promotes GEO BON activities. This committee will report to the GEO BON members at Plenary meetings of GEO BON Participants. The Steering Committee would establish, as needed, a variable number of **GEO BON Working Groups** with defined objectives and lifetimes, to fulfill certain tasks and/or activities of the GEO BON network.

A network as complex as GEO BON would not be able to function without some staff dedicated to supporting its efforts and the work of the Steering Committee. These persons would function as a "central communications and coordination office", but it is not anticipated that this would be established as a free-standing entity. Rather, it is suggested that this be a group of individuals, perhaps directly hired or perhaps seconded from member organisations, who would be housed within the GEO Secretariat and/or within relevant GEO BON participant organisations. Such an arrangement would be beneficial to the interactions between GEO BON and the networks established by the other GEO SBAs.

3.2 GEO BON data

GEO BON has been motivated by critically important information needs at local to global scales, but the GEO BON system will largely be built from contributing systems that have their primary responsibility at national or sub-national scales.

3.2.1 Inventory of existing data resources

Although lists of available biodiversity data do exist, they are neither comprehensive nor organised. Nonetheless, any strategic design for GEO BON should be based on a clear understanding of what does already exist, and what could or would be made available. We need to know the scope, scale, and resolution of the relevant datasets and what they collectively hold, as well as what they do not. Data from all main providers would be necessary to a reasonably complete survey.

Such a "gap analysis" is critically important in the process of designing a biodiversity observation system. It can also act as a community-building tool. The identification of key gaps informs the observation system and the network structure, because the analysis 1) provides a starting point for the biodiversity observing system, and 2) pinpoints specific projects that can be prioritised and allocated to teams.

3.2.2 Technical Issues

Handling data in such a way as to make them interoperable across biodiversity and the rest of biology, as well as with data types from other GEOSS areas, requires community-wide participation in the development of standards for data and metadata, and agreed-upon protocols and architectures for systems. In many ways, the World Wide Web is growing organically and advantage can be taken of developments in other areas and disciplines. Nonetheless, it will be necessary for GEO BON to take a leadership role in promoting biodiversity community participation in standards development for interoperability of data types from across the levels of biological organisation. It is not the purpose of this document to present details of the technical developments that will be needed, but rather to emphasise that these are of paramount importance and must be of highest priority as GEO BON becomes operational, and that there are partners that stand ready to contribute what they have already done in this area so that there is no unnecessary re-invention.

3.2.3 Future data collection

The information architecture for handling existing observations is of highest priority, but close behind it is the need for the establishment of data collection protocols for future monitoring and research that will facilitate the rapid incorporation of new observations into the system. Going forward, a role for GEO BON will be to encourage the widespread use of a core set of variables to be recorded during

data collection, but such a list will of necessity have to be developed through a consultative process. GEO BON through its participants can play a leadership role in encouraging the use of well-thought-out, community-adopted standards in this area, such as the use of "sparse hierarchies" and statistical interpolative models.

4 BUSINESS PLANNING

4.1 Initiating GEO BON

The suggested implementation approach is perhaps best summarised as "incremental, opportunistic, and organic". Note that "opportunistic" and "organic" in no way imply a lack of directional guidance. One of the important early tasks for GEO BON is to decide the mechanism by which it would provide such directional guidance, as well as a framework for development and growth.

The planning and coordination process can ongoing as the Early Products provide visibility and attract more partners. Such open-ended processes will be more inviting to prospective participants.

One of the biggest challenges for any new network is to gain enough members so that "critical mass" is reached. Therefore, gaining the early participation from key data providers and holders through to global network infrastructures that together can provide access to a large volume of data is the easiest and fastest way to move toward critical mass. Once some of these key players (such as GBIF, WCMC, NASA, USGS, and others represented at the April 2008 workshop) are on board, it will be possible to begin to shift outreach efforts to additional regional and local providers.

Incremental growth is a key feature of GEO BON. It will grow gradually, as opportunities arise, within a broadly defined framework of goals and standards. GEO BON will be dynamic, and never "finished"-- new systems will be added periodically, when available, and others may disappear or be replaced. However, GEO BON will be able to build upon existing frameworks such as GBIF, ILTER, etc. to more rapidly construct the GEO BON system of systems.

4.2 Development and sustained operation of GEO BON

Development and operation of the GEO BON network will depend on its capacity for processing and sharing information and analyses of biodiversity status, trends, and functions, as called for by the international community in order to improve environmental management and human well-being. A viable GEO BON requires a core operating capability that includes basic functions such as:

- Reporting on biodiversity (ecosystems, species, genes) status, trends, services, risks, and conservation
- Encouraging and facilitating the development of a network of biodiversity observations worldwide (this is an ongoing process)
- Encouraging and coordinating sharing of existing observations
- Identifying gaps in implementation that need to be filled
- Encouraging and coordinating use of GEO BON framework and variables for collection of new data
- Facilitating collection of long term *in situ* and remotely sensed observations
- Providing a conduit to members for requests for new products or services
- Organising dialogs with other SBAs of GEO, and identifying opportunities for collaboration
- Organising business meetings of GEO BON Steering and other committees
- Reporting to various stakeholders

The organisational structure and human resources of GEO BON remain to be decided. It is clear from the list above that in order to coordinate activities and bring partners together, GEO BON will need some form of concrete existence. However, this existence should not be as an entity parallel to GEO

but within the context of and in concert with GEO. The nature of that existence should be the subject of an ongoing conversation among GEO and the likely GEO BON participants. It is conceivable that some of the latter may offer staff secondments to GEO for servicing GEO BON or, alternatively, workspace and collaborative opportunities for staff dedicated to GEO BON.

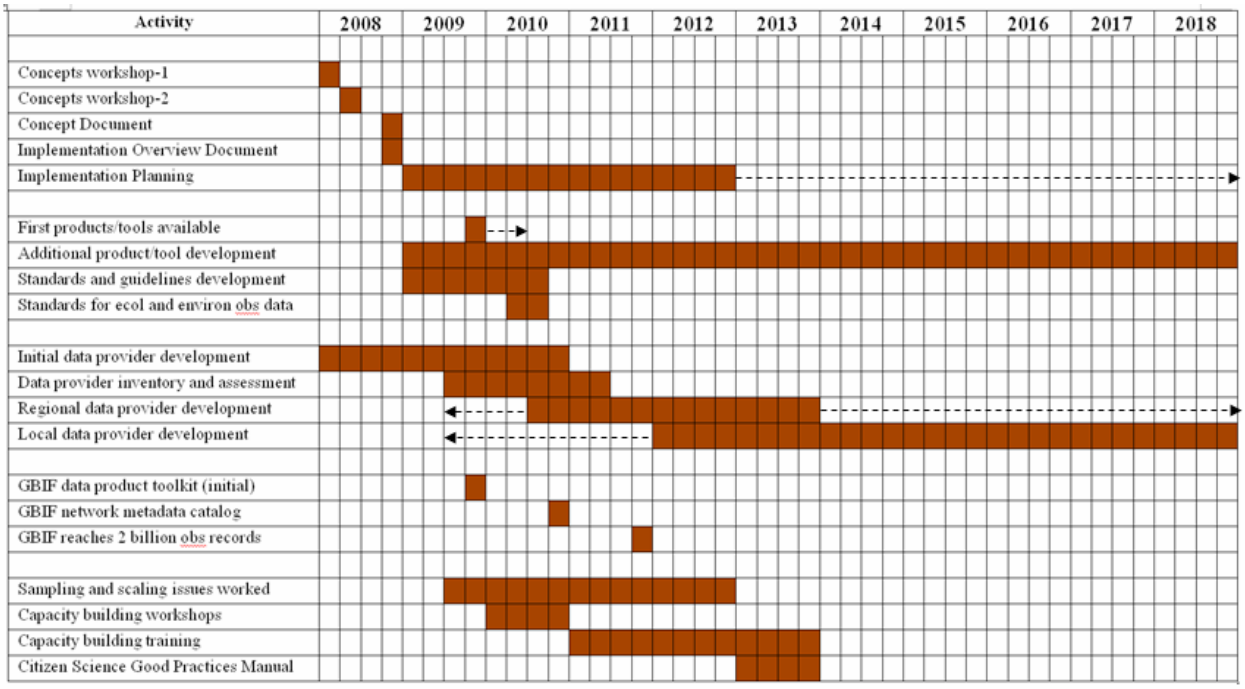
The advisory working groups that were organised at the April 2008 meeting in Potsdam can form the core of GEO BON Working Groups that will develop fully fleshed out plans for various tasks. Some of the advisory working groups have already produced prototype documents that can seed the process of development of components of an evolving, more detailed GEO BON implementation plan.

4.3 Supporting GEO BON projects

Though some basic support for GEO BON operations is needed to assemble and coordinate a viable network, there is a clear consensus across the GEO BON community that it is best to cast a wide net in the development and implementation of projects. Sharing costs, effort, data, personnel, and equipment among participants (members and nonmembers alike)—such as nongovernment-nonprofit, multilateral, for-profit, foundation, and academic institutions—is a basic operating assumption. Most projects are expected to be developed directly by GEO members. These projects may take the form of, for example, coordinated in-country projects, the results of which will be made available through the network, and GEO BON working groups and other GEO tasks may make recommendations about product needs, specific coordination needs, or necessary data standards and protocols.

4.4 Initial GEO BON Timeline / Roadmap

A very preliminary "roadmap" that lays out some of the most important GEO BON activities and milestones is presented in the chart below. In addition to GEO BON activities and milestones some GBIF milestones are included as these are pertinent to GEO BON development. One notable milestone is the availability of some of the Early Products described in an earlier section. Additional products are expected to be added continuously, again consistent with an incremental development approach. As indicated in the chart (and consistent with the concept of incremental development), planning is an ongoing process, though most concentrated at certain times.



GEO BON Timeline / Roadmap

4.5 Assessment and risks

Many of the challenges faced by GEO BON have been addressed above, and more detailed discussion will appear in later documents. Here, however, we provide a brief additional discussion to convey a sense of the degree of difficulty in implementing GEO BON.

In general, challenges fall into four categories: scientific, technical, social, and practical. Some of the scientific challenges are significant, in particular those dealing with integration and use of data from different scales. Some of the technical challenges, such as data format and data architecture, are by themselves rather straightforward, as much technology already exists that can support GEO BON, at least for the short to medium term.

However, the social and practical challenges associated with using that technology can be significant. Areas in which these challenges will arise include

- Mobilising the observations
- Growing the network of data providers and holders
- Showing providers and holders that they will benefit from joining
- Standardisation--of both data formats and data content
- Coordination--how to make disparate data systems interact and look like a single system...yet maintain their separate identities
- Dealing with scaling issues
- Assuring that all data providers are given appropriate credit when their data are utilised by third parties

GEO BON's early success, as noted above, is dependent on developing the Early Products as proofs of concept and therefore attractants to new partners. For GEO BON to continue into the future and fulfill its promise, it will need to be recognised by the ultimate users—society—as a reliable entity that delivers useful information.

4.6 Next steps

Acceptance of the ideas in this *Implementation Overview* at the November 2008 GEO Plenary would lead to establishment of a formally recognised GEO BON. In early 2009, representatives of GEO and the other major initiatives that have already indicated a keen interest in GEO BON would address the questions that arise from the points brought up in this document, especially in Section 4.2 (Development and sustained operation of GEO BON). Following decisions on structure, the processes necessary to appoint Working Groups and advisory bodies would be put in place, and decisions made concerning the Early Products discussed in Section 2. Follow-on meetings of Working Groups and project teams would naturally flow from these decisions, as well as the iterative planning and coordinating processes indicated in Sections 3 and 4.

5 ACRONYM EXPANSION

CBD	Convention on Biological Diversity
CBOL	Consortium for the Barcode of Life
CIS BON	Citizen Science Biodiversity Observation Network
CITES	Convention on International Trade in Endangered Species
COP	Conference of Parties
CSIRO	(Australian) Commonwealth Scientific and Industrial Research Organization
EC-JRC	European Commission Joint Research Centre
EML	Ecological Metadata Language
ESA	European Space Agency
GBIF	Global Biodiversity Information Facility
GEO	Group on Earth Observations
GEO BON	Group on Earth Observations Biodiversity Observation Network
GEOSS	Global Earth Observation System of Systems
GLC2000	Global Land Cover 2000 (dataset)
GLCC	Global Land Cover Characterization
ICSU	International Council for Science
ILTER	International Long Term Ecological Research
IUCN	International Union for Conservation of Nature
NASA	National Aeronautics and Space Administration
NCBI	(United States) National Center for Biotechnology Information
NCEAS	(United States) National Center for Ecological Analysis and Synthesis
RSPB	(United Kingdom) Royal Society for the Protection of Birds
TDWG	Taxonomic Databases Working Group (now called Biodiversity Informatics Standards)
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
US EPA	United States Environmental Protection Agency
USGS	United States Geological Survey
US LTER	United States Long Term Ecological Research
WCMC	World Conservation Monitoring Centre
WWF	World Wildlife Fund