European Contribution to GEO BON

Report of an Electronic Conference, September 2008
for the European Contribution to GEO BON workshop organised by
Biostrat (www.biostrat.org)
25-27 September 2008, Cegléd, Hungary

Biodiversity
Observation
Network

E-Conference Organisation:

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Preface

Research on biodiversity is essential to help the European Union and EU Member States to implement the Convention on Biological Diversity as well as reach the target of halting the loss of biodiversity in Europe by 2010.

The need for co-ordination between researchers, the policy-makers that need research results and the organisations that fund research is reflected in the aims of the "European Platform for Biodiversity Research Strategy" (EPBRS), a forum of scientists and policy makers representing the EU countries and other members to the Framework Programme, whose aims are to promote discussion of EU biodiversity research strategies and priorities, to exchange information on national biodiversity activities and to disseminate current best practices and information regarding the scientific understanding of biodiversity conservation.

This is a report of the E-Conference entitled "European contribution to GEO BON" preceding the BioStrat workshop to be held at Cegléd, Hungary from the 25th – 27th September 2008.

Introduction

Katalin Török

This electronic conference is intended to provide information from the widest possible range of experts to a workshop, organised by the BioStrat project, which aims at developing links and instigating networks between the Global Earth Observation System of Systems (GEOSS, www.earthobservations.org) and the European Platform of Biodiversity Research Strategy (EPBRS, www.epbrs.org) The cooperation is meant to strengthen both sides by incorporating GEOSS objectives related to biodiversity in the EU Biodiversity Research Strategy, as well as incorporating European vision into the development of a global biodiversity observation network

GEOSS has nine Societal Benefit Areas (SBAs), one of which is Biodiversity. It has been decided that the main aim of this particular SBA should be to set up a Biodiversity Observation Network that should link together the world's many stand-alone biodiversity monitoring systems. Working towards this aim, the GEO Secretariat and DIVERSITAS joined forces to outline the framework of a Global Biodiversity Observation Network (GEO BON). Two other tasks of this SBA are to capture historical biodiversity data (lead by GBIF) and to build an Invasive Species Monitoring System (lead by the US).

GEO BON will create a global platform for integrating biodiversity data with data on climate and other key environmental and social factors. It will fill gaps in taxonomic and biological information and increase the pace at which information is collected and disseminated. The task of GEO BON is to develop a strategy for assessing biodiversity at both the species and ecosystem level, in order to facilitate the establishment of monitoring systems that enable globally coordinated assessment of trends and distributions of species and ecosystems of special conservation merit. An Implementation Plan is to be released by October 2008. Seven Task Groups (TGs) are currently working on the initial concept documents as follows:
- Data TG
- Network and Governance TG
- Scaling, Integration and Models TG
- Early Products TG
- Capacity Building TG
- Citizen Science TG
- Resources and Business Plan TG

EPBRS is a forum of scientists and policy makers, dedicated to the development of the European Biodiversity Research Strategy. In its biannual meetings during the last nine years it has focused on different research issues related to the above tasks (e.g. monitoring, scaling). Some new topics to be addressed by GEO BON, relevant to EPBRS, are to review and prioritize research and design decision-support systems that integrate monitoring with ecological modelling and forecasting. I sincerely hope that the themes discussed during the E-conference and its main outcomes can be channelled to both the EU biodiversity research strategy and the GEO BON Implementation Plan.

‘Ecosystems’ is another Societal Benefit Area of GEOSS which overlaps with GEO BON, as ecosystem classification and mapping are a common interest. Knowledge gaps in linking these two areas require research. For example, we lack approaches and possibilities to identify and map by remote sensing the environmental stress of ecosystems, a question raised by Biostrat partners. The integration of ecosystem and species level is another problem that needs further research. EPBRS by its long tradition of expert discussions that lead to ready-to-use products can also provide support to GEO BON on management issues, for example the facilitation of consensus on data collection protocols and the coordination of the development of interoperability among monitoring programmes. GEO BON will give a global view to EPBRS: in this way both programmes can mutually benefit from the collaboration.

The summary report of the E-conference will be presented at the GEO BON – Biostrat Workshop, 25-27 September 2008, Cegléd, Hungary. The main conclusions of this summary will serve as the basis for the recommendations to be prepared by the meeting participants.

Summary of Contributions

Fiona Grant and Allan Watt

European Contribution to GEO BON

In her introduction to the GEO BON e-conference, Katalin Török set out the main aims of the e-conference, namely to provide information from a range of experts in order to develop links and instigate networks between the Global Earth Observation System of Systems (GEOSS) and the European Platform of Biodiversity Research Strategy (EPBRS).

In response to the introduction, Daniel Faith noted that as well as observation goals for ecosystems and species, GEO BON will also facilitate the global monitoring of genetic diversity, using a combination of remote sensing and in situ approaches, and highlighted that these will be most effective when integrated with GEO BON observation strategies at species and ecosystem levels. A new type of fast and easy-to-use identification service for species was introduced by Mauri Ahlberg, which she believed would greatly promote any Global Biodiversity Observing System.

Cornelia Nauen called for emphasis to also be placed on the systematic extraction of information from the scientific literature, in particular historical records and associated ecological information, so as to combine with earth observation of habitats (and their change over time), in situ observations and genetic studies. Donat Agosti agreed with Cornelia's emphasis for the improvement of the use of literature. He argued that full text publications need to be made available in a machine readable format so that the machine is able to find all taxonomic names, geographic entities and much more. He outlined current systems available in order to begin this process. The significance of historical records was re-emphasized by Simon Tillier, who also highlighted the importance of keeping specimens in taxonomic collections as an objective reference to the occurrence of species.

Doug Muchoney's contribution outlined how GEOSS (Global Earth Observing System of Systems) can aid current biodiversity monitoring systems by creating links with other Earth Observation networks to help fill in gaps in our present taxonomic and biological knowledge, generate updated assessments of global biodiversity trends, track the spread and retreat of invasive alien species, and monitor how biodiversity responds to climate change. Rob Jongman also indicated the need to develop a monitoring approach that covers all aspects of biodiversity in one coherent system and the potential for Earth Observation to contribute to this monitoring system to provide a vehicle for generalisation of observations and a context to field samples.

Anne Larigauderie and Bruno Walther outlined the key concept of GEO BON as a shared and interoperable system bringing data of different types and from many sources to bear on the information needs as defined by users. They highlighted GEO BON's main aims which are to create a global network from the many already existing efforts by linking and supporting them within a scientifically robust framework, and using the best technologies available. Rob Jongman also recognized the need for a cost-efficient data collection system for biodiversity that is linked to a sound institutional framework in order to harmonize and share monitoring approaches at a European scale.

The technological requirements in order to be able to monitor biodiversity at global and intervening scales was addressed by Zoheir Sabeur who noted the need for the deployment of open systems around the world in order for scientists to get the bigger picture of the state of our biodiversity and ecosystems. Gediminas Vaitkus outlined the Experimental High-Resolution Information System (HIRIS) of the Baltic Sea and Europe, as a multi-purpose open structure statistical grid system that could be used for the deployment, processing and analysis of the diversity of ecosystems, biocenoses and species. He proposed the system to be an on-line service covering the whole of Europe with a broad range of thematic information and specifically targeted at high-resolution continental-scale modelling of environmental and socio-economical processes.

Some potential research needs relating to the required integration of decision-support systems, modelling, and forecasting were raised by Daniel Faith. He argued that effective biodiversity spatial modelling approaches are needed in order to add value to primary biotic observations through integration with key environmental variables. He suggested that such research is needed to enable better estimates of land condition in critical places, which in turn may result in a reduced rate of biodiversity loss. Gediminas Vaitkus outlined the RGB clustering method as a classification method for automated production of thematic land cover datasets. He argued that landscape structure and diversity are critical factors for the quality and diversity of biocenoses, and therefore the application of standard methods for rapid extraction of specific land cover thematic information from satellite images is essential for mapping landscape structures and identification of ongoing changes in a study area.

Klaus Henle called for emphasis to be placed on bridging the gaps between theoretically ideal monitoring approaches and real world constraints. He also highlighted the need to further explore and strengthen the role of volunteer involvement in monitoring, and to explore the geographic and expansion of web-based monitoring overviews and support tools developed in EU projects. Similarly Zoheir Sabeur recognized the need for near real-time monitoring of biodiversity at a global scale and argued that multidisciplinary approaches are required in order to achieve this.

Research Priorities

Fiona Grant and Allan Watt

1. Research needed to improve biodiversity monitoring:

- Develop multidisciplinary approaches to monitoring biodiversity globally in near real-time.
- Develop a monitoring framework that covers all aspects of biodiversity in one coherent system, including genetic diversity, species diversity and ecosystem diversity.
- Bridge gaps between theoretically ideal monitoring approaches and real world constraints to further strengthen the role of volunteer involvement in monitoring.
- Explore the geographic and expansion of web-based monitoring overviews and support tools developed in EU projects.
- Understand the sensitivity of volunteer-based monitoring to the cultural, political and economic conditions of a country, particularly non-European countries.
- Support integration of in situ and earth observation by inter-calibration of EO and field observation at the habitat scale.

2. Research needed to improve technological tools:

- Develop better and sustained observation systems, nested global sampling, and modelling, computational and analytical tools.
- Make full text versions of publications available in machine readable form.
- Develop ways to convert current publishing workflows into one that has underlying XML, in order to allow automatic extraction of data.
- Develop effective biodiversity spatial modelling approaches that can add value to primary biotic observations through integration with key environmental variables.
- Enable better estimates of land condition, and support the interpretation of observations through the lens provided by the biodiversity models.

3. Research needed to improve data collection systems and databases:

- Develop a cost-efficient data collection system for biodiversity linked with extant data at national, regional and continental levels to produce statistical estimates of stock and change of key indicators and a system for estimating change for forecasting and testing policy options.
- Develop a common reference dataset, against which LTER and Natura 2000 sites can be compared and the impact of conservation policies reviewed.
- Expand and broaden the scope of web-based databases to provide an overview of monitoring activities outside Europe.
- Develop web-based support tools for monitoring activities, such as BioMAT.
- Extract information, in particular historical records and associated ecological information, and combine with earth observation of habitats (and their change over time), in situ observation and genetic studies, as appropriate.
- Maintain taxonomic collections and allow access to the information which they contain.

List of Contributions

European contribution to GEO BON

European Contribution to GEO BON

RE: Introduction to 'European Contribution to GEO BON'

Daniel Faith, Australian Museum, Sydney, Australia

The introduction to this conference noted GEO BON observation goals for ecosystems and species. In addition, GEO BON will facilitate the global monitoring of genetic diversity, using a combination of remote sensing and in situ approaches. These approaches often will be most effective when integrated with GEO BON observation strategies at species and ecosystems levels.

In the GEO BON draft concept document, we highlight three broad strategies for observations/analyses of genetic diversity that can be addressed by GEO BON:

1. Repeated observations, over time, of specific genetic components of interest, in selected target species.
2. Repeated observations, over time, of other biodiversity components (e.g. range extents for a representative set of species), integrated with models that create links from these observations to genetic diversity.
3. Repeated observations, over time, of changes in land/water condition (e.g. using remote sensing), integrated with spatial genetic variation models that act as the "lens" for inferences about the corresponding changes at the genetic level.

GEO BON will promote these overlapping strategies for a range of monitoring approaches, extending from detailed observations for key species to model-based inferences of more general changes in genetic diversity. Changes in genetic variation may be based on direct observations, or inferred indirectly through a combination of remote sensing and biodiversity models.

GEO BON faces a number of interesting issues in addressing genetic diversity; for example:

- The role of models that use changes in range extent of a given species to predict corresponding changes in genetic diversity
- The role of DNA bar-coding databases

RE: Introduction to 'European Contribution to GEO BON'

Cornelia Nauen, European Commission, Belgium

Emphasis should also be placed on extracting information systematically from the scientific literature, particularly historical records and associated ecological information so as to combine with earth observation of habitats (and their change over time), in situ observation and genetic studies, as appropriate. Without systematic use of scientific libraries and historical records observation of the current situation might otherwise fall prey to the shifting baseline syndrome; conversely, complementary approaches offer novel opportunities at formulating and testing hypotheses that are not only scientifically challenging, but also highly relevant to policy, land, water and resources management and many social and economic issues.

RE: Introduction to 'European Contribution to GEO BON'

Donat Agosti, Plazi, Bern, Switzerland

Cornelia Nauen makes a very important point: The use of literature. There are two aspects in this, the legacy and the prospective literature.

The Biodiversity Heritage Library (BHL) is currently engulfed in digitizing biodiversity literature sitting in the major US/UK institutions aiming at well over 100 M pages of printed records. However, the really important breakthrough will come at the point where the full text version of publications are available in a machine readable form, meaning that a machine would find all the taxonomic names, geographic entities and much more, such as where a description begins and ends. Only this would allow us to know, what geographic name belongs to which species, as Cornelia points out.

To get this done is not a trivial task. At Plazi (http://plazi.org) we have set up a system that allows semiautomatic conversion of scanned documents to XML documents including all the relevant tags, using GoldenGate. From there, the marked-up documents are imported into a database in which the treatments can be read, most of them enhanced with links to external resources (see http://plazi.org:8080/GgSRS/search): see for example a recently published article in PloS One on Anochetus, where links have been added even to the individual gene sequences or the collecting events (http://plazi.org:8080/GgSRS/html?8AD0DAEF2180649D27DBA7CE08E4FF93). The collecting event can then be harvested by the Global Biodiversity Information Facility (GBIF: see http://data.gbif.org/datasets/provider/241/), using a TAPIR protocol. This way, taxonomic publications can be harvested and its content be used.

Legacy mark-up is expensive and needs human interaction. Furthermore, the older the publication the less detail on geographic information, and therefore, it is clear, that the future lies in prospective mark-up of publications. That means that each publication should include the basic elements to allow the machine to extract descriptions, geographic data, taxonomic names and more. Together with the National Library of Medicine, such an XML scheme is currently being developed, that includes all the taxonomic elements. It would now be very important to find ways we could help to convert current publishing workflows into one that has underlying XML, which would allow automatic extraction.

Finally, the use of unique identifiers, such as LSID being proposed by the Taxonomic Data Working Group (TDWG) would help to include links in the publications to external resources, such as names or specimens. In Zoology, Zoobank has been deployed to support this effort for zoological names.

If one looks ahead, more and more specimen data is accompanied by DNA sequences, standard scientific imaging, date and GPD records. If this is all accessible from semantically enhanced publications (see the case of Anochetus boltoni above), we immediately have a very rich data source at hand.

Finally, dealing with species description is also a solution to overcome the copyright issue of publications that prohibit a global network of linked descriptions (see e.g. http://hdl.handle.net/10199/19076).

RE: Introduction to 'European Contribution to GEO BON'

Simon Tillier, European Distributed Institute of Taxonomy (EDIT), Paris, France

As stated by Cornelia Nauen, the importance of historical records cannot be overemphasized, and GEO BON should integrate, or be interconnected, with information system infrastructures providing access to these records. The Biodiversity Heritage Library project aims at digitizing all the available taxonomic literature, which contains a large proportion of all species occurrence historical records, and indexing it. However, even with access to this resource, we must not forget that application of species names is subjective, and that often species names do not designate the same concept over time. Ultimately the only objective testimony of the occurrence of a species in any place at any time is a documented specimen, which justifies maintenance of taxonomic collections and access to information which they contain, as provided by the GBIF. The ESFRI initiated LifeWatch programme aims precisely at interconnecting and making usable all these various sources of records, including modern and present observation records, making them available and providing the adequate analytical tools. The resulting infrastructure should constitute an important component of GEO BON.

Geographically-Distributed Ecosystem Monitoring Service

Zoheir Sabeur, BMT Limited, Southampton, UK

I would like to address the technology required to be able to monitor our biodiversity at global, but intervening, scales. I strongly believe that the deployment of open systems around the world will enable scientists to get the big picture of the state of our biodiversity and ecosystems. Furthermore, these services can be chained to other existing services which are emerging around the EU, US, Asia and Australia. As the chairman of the Environmental Monitoring Panel of experts under ECOR (Engineering Committee on Oceanic Resources) we are addressing such issues in an integrated and generic way. However, we would require multidisciplinary approaches to address the monitoring of biodiversity in near real-time, globally. I would like to open the discussion with the following questions:

1. Can biodiversity be monitored globally using access to geographically-distributed data sources of environmental monitoring?
2. Is the use of open geospatial services technology the way forward to achieve point 1?
3. Can we achieve multiple time-scale trends of biodiversity changes using such technologies?
4. Can we intervene in good time to mitigate the declines of geographically-located biodiversity under such monitoring systems?
5. Are there enough research funds and support for putting in place such monitoring technologies?

Promoting Citizen Science and Biodiversity Research

Mauri Ahlberg, University of Helsinki, Finland

At the University of Helsinki we have developed a new type of fast and easy-to-use identification service for species. It would greatly promote any Global Biodiversity Observing System.
Please check this for yourself at: http://www.naturegate.net

For more information please email: mauri.ahlberg@helsinki.fi or look at our website: http://www.helsinki.fi/people/mauri.ahlberg

Earth Observation Science Requirements for Characterizing and Monitoring Biodiversity

Summary: This contribution outlines how GEOSS (Global Earth Observing System of Systems) can aid current biodiversity monitoring systems by creating links with other Earth Observation networks to help fill in gaps in our present knowledge.

Douglas Muchoney, Group on Earth Observations (GEO), Geneva, Switzerland

The Convention on Biological Diversity defines biodiversity as “the variability among living organisms from all sources including, among other things, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems" (CBD, 1992). The consequences of changes to and loss of biodiversity are manifold but particularly acute for alteration of ecosystem services (Chapin et al., 2000). While much is known of the status of certain species and ecosystems, there are still huge gaps in our knowledge

Earth observations, comprising of satellite, aerial, and in situ systems, are increasingly recognized as critical observations for monitoring the Earth system and systems (Muchoney, 2008). The Group on Earth Observations, GEO, was established to implement the Global Earth Observing Systems of Systems, GEOSS, which includes in its mandate the protection of ecosystems — Improving the management and protection of terrestrial, coastal, and marine ecosystems, and understanding, monitoring, and conserving biodiversity.

In the context of biodiversity, GEOSS will link the many stand-alone biodiversity monitoring systems and connect them to other Earth observation networks that generate relevant data, such as climate and pollution data. It will also help to fill in gaps in taxonomic and biological information, generate updated assessments of global biodiversity trends, track the spread and retreat of invasive alien species, and monitor how biodiversity responds to climate change (GEO, 2005).

GEOSS is envisioned to unify many disparate biodiversity and ecosystem observing systems and create a platform to integrate biodiversity and ecological data with other geo-spatial data. This will support monitoring of the condition and extent of ecosystems, and the distribution and status of species. The GEOSS Architecture Components specify automated and manual components of remote-sensing and in situ systems, the integration of national, regional and global data centres, as well as discipline data centres, access to data and to metadata about archived and on-line holdings, and planned data acquisitions.

The European Platform for Biodiversity Research Strategy (EPBRS) is harmonizing international initiatives including GEOSS and the GEO Biodiversity Observation Network, GEO BON. BioStrat is promoting science and policy, and offers an important mechanism for harmonizing research requirements for Earth observations. Key research requirements include better and sustained observation systems, nested global sampling, and modelling, computational and analytical tools.

Toward a Global Biodiversity Observing System

Anne Larigauderie and Bruno Walther, DIVERSITAS, Paris, France

Summary: To support the implementation of the conceptual approach for GEO BON at the European scale, we provide below essential background information about the on-going process toward a global biodiversity observing system.

The Group on Earth Observations (GEO) was launched in 2002 in response to the widely-identified need for adequate information to support environmental decision-making. GEO is a voluntary partnership of 73 national governments and 46 participating organizations. It provides a framework within which these partners can coordinate their strategies and investments for Earth observation. The GEO members are establishing a Global Earth Observation System of Systems - GEOSS - (www.earthobservations.org) that provides access to data, services, analytical tools and modelling capabilities through a web-based GEO Portal (www.geoportal.org). GEOSS has identified nine priority 'societal benefit areas' in its first decade. Biodiversity is one of them. NASA and DIVERSITAS, the international programme of biodiversity science, accepted the task of leading the planning phase of GEO BON and are supported by the GEO Secretariat.

In collaboration with various individuals and organizations, they are developing a Concept Document (Andrefouet et al. 2008) and an Implementation Plan for the proposed Group on Earth Observations Biodiversity Observation Network (GEO BON) which is envisaged to be a new global partnership to help collect, manage, analyze and report on data relating to the status of the world's biodiversity (http://www.earthobservations.org/cop_bi_geobon.shtml; Walther et al. 2007; Scholes et al. 2008).

The process to develop GEO BON took shape in April 2008, when some 100 biodiversity specialists representing over 60 scientific and intergovernmental organizations met at Potsdam, Germany, to complete the Concept Document (Andrefouet et al. 2008). Seven working groups have since then been formed to draft an initial Implementation Plan by the end of the year 2008 for presentation at GEO V (Bucharest, Nov 2008). These are: early scientific products; capacity-building; citizen-science; data issues; funding & resources; network & governance; scaling, integration & models.

The key concept is a shared and interoperable system bringing data of different types and from many sources to bear on the information needs as defined by users (see figure one). GEO BON aims to create a global network from the many already existing efforts by linking and supporting them within a scientifically robust framework, using the best technologies available. The role of GEO BON is to guide data collection, standardization and information exchange. The participating organizations retain their mandates and data ownership, but agree to collaborate in making part of their information accessible to others.

Using the GEO BON Concept Document (Andrefouet et al. 2008) as a starting point, we hope that the BIOSTRAT meeting will be able to discuss this conceptual approach at the European scale and come up with research priorities to support the involvement of the European community into the implementation of GEO BON.

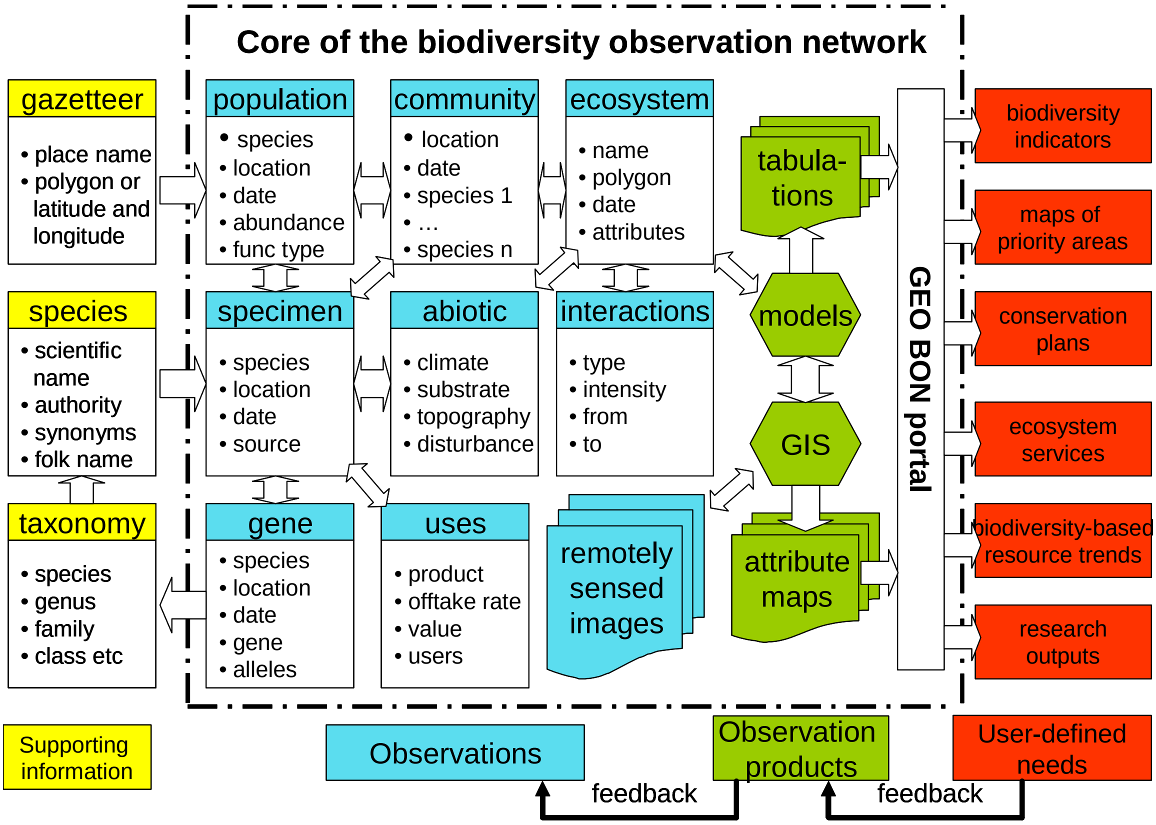

Figure 1: A schematic representation of the core data types, observation products and end uses of an integrated biodiversity observation system. Most of the elements already exist, but are incomplete or dispersed among a wide range of partners. The proposed implementation strategy involves linking them using data-sharing protocols, followed by incremental, needs-led and opportunistic growth. From: Scholes et al. 2008, Science 321:1044-6

Observing Genomes, Species and Habitats in a Cost-Efficient Way

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Summary: This contribution highlights the need for a cost-efficient data collection system for biodiversity that is linked to a sound institutional framework in order to harmonize and share monitoring approaches at a European scale. The author also indicates the need to develop a monitoring approach that covers all aspects of biodiversity in one coherent system and the potential for Earth Observation to contribute to this monitoring system to provide a vehicle for generalisation of observations and a context to field observations.

Rob Jongman, Alterra, Wageningen UR, The Netherlands

The framework:
What are the key issues in biodiversity monitoring and why do we not invest in biodiversity monitoring? These are interesting questions when developing a vision on how to carry out monitoring. In an interview for the RUBICODE project one of my colleagues received the answer that the total Nature Conservation budget available in one of the German Bundesländer would be needed to fulfil the requirements for Natura 2000 (Natura 2000 is the EU system of protected areas) monitoring.

This answer can be interpreted in two ways: (1) their budget is too small or (2) the monitoring system is not efficient. It might be that the latter is truer than the former; at least cost-efficiency should be considered. However, most ecologists are not interested in cost-efficiency, but in the species group they are working on. For many ecologists the truth is in the field and not in statistics.

GEO BON has the task to set up a world wide monitoring system to be used for reporting to conventions on developments in reaching Millennium Goals. In Europe there is also a process of developing a European Union. One of the consequences of having a European Union is that national approaches should be transformed into European approaches and that databases have to be harmonised and shared. That has several consequences for monitoring biodiversity. Questions that used to be clear in a national context have to be reconsidered, such as:

1. What should be monitored, and how?
2. How to harmonise monitoring approaches to make joint reporting possible and data comparable?
3. How to develop quality standards?
4. How to monitor cost-efficiency?

Therefore, the key challenge for GEO BON is the development of a cost-efficient data collection system for biodiversity linked with extant data at national, regional and continental levels involving a sound scientific basis for the production of statistical estimates of stock and change of key indicators and a system for estimating change for forecasting and testing policy options.

It is essential that this scientific basis is linked to a sound institutional framework to ensure continuity and long term collaboration. This is simply said, but it means that the institutions involved should be willing to share metadata, agree on definitions and be willing to exchange data.

According to the CBD, biodiversity indicators are to be used as information tools summarizing data on complex environmental issues to indicate the overall status and trends in biodiversity. Policy makers set targets and it is the task of science to determine measurable indicators that can be consistently monitored in time and space. This means permanent interaction and reporting.

Biodiversity has different patterns in different parts of the world. In extensive natural areas such as savannahs, tropical forests and tundra the species pattern will be different from the pattern in the cultural landscapes in Mediterranean Europe. In Europe biodiversity is found in both protected natural areas and unprotected cultural landscapes, which form the major part of Europe's countryside. Whilst special sites are covered by Natura 2000, the majority of common biodiversity resides in ca. 85% of the land that is outside protected areas, e.g. birds in hedgerows. Changes are therefore not caused by impacts on quality and size of the reserves, but also by the land use change and management in the wider countryside. The whole complex must be monitored to get the full picture.

A field observation network:
It is important to develop a monitoring framework that covers all aspects of biodiversity in one coherent system, including genetic diversity, species diversity and ecosystem diversity. One of the basic questions is how these three levels of genes, species and ecosystems are linked in time and space. The population concept is central in evolutionary and conservation biology, but identifying the boundaries of natural populations is difficult. Populations of species can show differences in genomes (Manel et al., 2007). A monitoring approach should cover the spatial genetic structure as well as the species and the ecosystem structure.

A systematic field monitoring approach for Europe or any other continent must consist of several steps and every action for collection of new data will first need to consider what existing data are available and how they can be used and interpreted. Some key biodiversity indicators can be linked to ecosystems or habitats e.g. the large blue butterfly with calcareous grasslands. The monitoring system should consist of a baseline monitoring system combined with selected sites for intensive sampling in conservation sites (such as Natura 2000) and sites for Long Term Ecological Research (LTER/NEON) on the cause-effect relationships at the site level. For the wider landscape an approach for habitat monitoring has been elaborated for Europe by Bunce et al. (2007) and it can be applied in other continents as it is based on life form classifications.

For cost efficiency and proper use of statistics an important question to be solved in this is "how to define and select monitoring sites across Europe (or other continents), so that meaningful (significant) conclusions regarding trends in biodiversity can be documented in a balanced way, including rare phenomena"? Protected areas will probably show different trends and more rare habitats than the wider countryside. There is therefore no doubt that it is essential to have a common reference dataset against which LTER and also Natura 2000 sites can be compared and to review the impact of conservation policies. Such a 'control' dataset is essential to assess the effectiveness of policies and the degree of representativeness of recording systems as discussed at several EPBRS meetings and the GBIF workshop on biodiversity at the ecosystem scale, held in Aarhus in April 2006.

Earth observation:
Principally, for some habitat types, quite detailed types can be distinguished using Earth Observation (EO), such as forest types and vegetation structure. A range of projects are ongoing utilising EO data for land cover characterisation, landscape structure and biodiversity recognition. Remote sensed data and field data are not often integrated (Wyatt et al., 2004). Trials have been carried out for full integration between in situ and earth observation and results are improving (Fuller et al., 2005). New sensor and multi-temporal approaches such as phenology mapping can contribute to this. EO can contribute to a biodiversity monitoring system providing a vehicle for generalisation (i.e. extrapolation) and context to the field samples:
− Vehicle for interpolation and generalisation: The concept of linking EO derived landscape and land cover information with field data to generalise observations on biodiversity is based on the premises that a relationship exists between the composition and structure of the landscape and the diversity of (ecosystems) habitats and the species and genotypes that may be present within.
− Context: EO can deliver data on land cover, phenology and landscape structure features complementing the observed species and habitat data and in some cases (e.g. linear features) it may deliver proxies for field observation.

Differences exist in habitat types between field observation and earth observation because some cannot be covered well by one of the two; such as bogs that are better covered by earth observation and linear features that are better covered by field observation. Fuller et al. (2005) state "the field survey essentially presents a 'caricature' of the real world: complex land cover patterns, continuously variable in space and time, are artificially recorded as discrete features". One of the problems of earth observation is that rare habitats and complex cultural landscapes are not well covered. Also most species cannot directly be interpreted from EO data. Therefore inter-calibration between EO and field observation needs further work (Fuller et al., 2005). As it is not possible to link most species data to EO data the intermediate is the habitat data that can be generalized to both species and EO data.

Research Strategies for Integrating Monitoring Activities in the Real World

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Klaus Henle, UFZ – Helmoltz Centre for Environmental Research, Leipzig, Germany

Summary: Based on experience from recent EU projects we recommend that strategic research focuses on bridging the gaps between theoretically ideal monitoring approaches and real world constraints to further explore and strengthen the role of volunteer involvement in monitoring, and to explore the geographic and, topically, expansion of web-based monitoring overviews and support tools developed in EU projects.

Biodiversity monitoring programs are critical to evaluate the success of conservation policies and biodiversity management. Nevertheless, monitoring is a highly decentralized activity, which makes it difficult for researchers, resource managers, or conservation planners to get a good general picture of what real-world monitoring programs entail. A number of recent reviews have made recommendations for monitoring programs, and research for the optimal design of monitoring programs has become a fertile research area. However, there is little information available on how these recommendations match the reality of monitoring programs. This means that it is often challenging for those involved in monitoring to know whether their programs are compatible with the programs of others. This is even the case for monitoring legally required by the EU Habitats Directive. For global initiatives such as GEO-BON, this challenge is considerably magnified.

Europe has tackled these challenges in various research projects, recently in the targeted projects EuMon and EBONE and also by ETC Biodiversity and the Scientific Working Group of the Habitats Committee, DG Environment. The experience gained in these activities could provide a particularly valuable EU input to GEO-BON. The following suggestions for strategically important research are derived from this experience:

A. The experience has shown that suggestions made in the high profile literature are idealistic and have little chance of implementation except for high profile or particularly economically valuable biodiversity components. Therefore, research should address how an optimal compromise between theoretically ideal monitoring approaches and the real world of biodiversity monitoring can be found. This comprises of, among others, how constraints of real world monitoring can be reduced and further improvement and exploration of approaches to integrate disparate monitoring activities. Research on the latter should focus on methods and approaches on the one hand and on the other side practical tests of bringing together currently separate monitoring schemes for a broadening of the taxa used as headline indicators.

B. Apart from habitat monitoring by remote sensing, biodiversity monitoring will also heavily rely on volunteers in the future. Recent analyses by EuMon have shown that volunteer based monitoring schemes match professional schemes in terms of many criteria that reflect scientific quality of monitoring output. In addition, it considerably strengthens the profile that biodiversity receives by the general public. There is a high, but only partially realized potential in Europe, and probably elsewhere, for further volunteer involvement and topically broadening biodiversity monitoring. Successful recruitment and maintenance of volunteer-based monitoring is very sensitive to the cultural, political, and economic conditions of a country and these should be further addressed to provide guidelines beyond European countries.

C. The expansion of web-based databases that provide an overview of monitoring activities to geographic regions outside Europe and the broadening of the topics covered, for example to facilitate the compilation of trends observed in the various monitoring programs, is also of strategic importance. The same applies to web-based support tools for monitoring activities, such as BioMAT. Here it should be tested to what extent the needs of countries outside Europe are covered; whether all major monitoring approaches, e.g. remote sensing, are sufficiently integrated; and whether it is feasible to expand it to an online support system, in which monitoring coordinators can find help and the scientific community can offer help to analyse and integrate monitoring data.

HIRIS - Experimental High-Resolution Information System of the Baltic Sea Region and Europe

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The Lithuanian Scientific Research Institute (Institute of Ecology of Vilnius University) in co-operation with a commercial GIS Service Provider (Institute of Aerial Geodesy) are working on the implementation of a multi-purpose open structure statistical grid system over the entire European continent, which among other thematic areas could also be used for deployment, processing and analysis of diversity of ecosystems, biocenoses and species. Some countries have already made attempts to implement such information systems locally (see an example of Statistics Finland: http://www.stat.fi/tup/ruututietokanta/index_en.html), but our ambition is to launch an operational on-line service covering the entire continent of Europe with a broad range of thematic information and specifically targeted at high-resolution continental-scale modelling of environmental and socio-economic processes, including different ecosystem/climate change and socio-economical development scenarios. The system would be distributed over many regional "nodes", but at the same time completely open and flexible in its architecture, so that it would allow immediate on-line access by research groups, updates of thematic content and independent development/simulation of different scenarios – whatever technical means are preferred by the users. The main objective of the system would be to serve as an open platform for operational support of environmental decision-making processes at an EU level, facilitated by scientific/professional advice, collectively formulated by on-line co-operating groups of professionals and researchers – all utilizing a multitude of processed thematic information resources available on HIRIS system (on-line database) on an operational 24/7 basis.

It would basically be a simple collection of GIS layers containing coverages of regular rectangular polygon features, or so-called "pseudo-raster grids", made at given resolutions (e.g. 1x1, 5x5, 10x10 km, etc.). Each of the individual features will be assigned unique HIRIS_ID feature identifiers. The pseudo-raster GIS coverages will be projected into a standard continental European coordinate system (ETRS89_LAEA), as specified in "EEA Guide to Geographical Data and Maps" version 1.3 (issued by EEA and EIONET in 2005). Those pseudo-raster polygon coverages (regular grids of polygons) will be used for geo-processing operations with a selected collection of thematic (presumably, land cover, administrative, environmental, etc.) GIS data layers, which in turn will be further analyzed by means of scripts, providing quantitative evaluations (as well as proportions) of thematic features, corresponding to the above-mentioned HIRIS_ID values of geo-located regular cells. So, the concept of the High Resolution Information System (HIRIS) is based on a simple and standard GIS components (collection of pseudo-raster statistical grids) and a large open-structure attribute and meta-database, which will be interactively accessible to the registered users on-line and actually contain all thematic spatial data processed into the system by the HIRIS team, and derived data variables produced by users during their analysis/modelling exercises - all available in the form of simple numeric data columns (including indexes and meta-data descriptors), each individual record (line) being indirectly geo-located by means of HIRIS_ID codes, linking multiple attribute records to corresponding pseudo-raster GIS cells. Display and visualization of results directly from HIRIS attribute datasets could be either personally done by the clients on their computers (using the same standard pseudo-raster grid coverages with HIRIS_ID - a total platform/software independent choice of GIS software on a client side), or by means of pre-defined customizable WMS (Web Map Server) interfaces.

We are looking forward to developing an "elegant" and platform/software independent technological solution, which would allow us to establish an interactive on-line service, where users (connected to the attribute database) will be able to perform any kind of queries, analyses, computing, modelling, etc. on the ′real′ numbers, and visualize the results on the GIS layers of the pseudo-raster statistical grids. In other words, they will have a large, flexible and spatially geo-located statistical data bank at their disposal, which would be able to incorporate virtually any type of spatial/temporal information and allow any kind of manipulation between attribute data columns, so that users will be able to run spatial models on their preferred analytical software without any need of specialized GIS software. The difficult part of it is initial geo-processing of large amounts of spatial data, but when it is done, working with numerical attributes is extremely fast and efficient, even in a multi-user environment.

CORINE Land Cover GIS databases were tested as one of the most interesting candidates for being processed into HIRIS. This is because I see this system as a good opportunity to operationalize the use of GMES Core Mapping Services products, maybe even forming a continuous chain of downstream products and services. Land cover data would become especially valuable to institutional users, when it is transformed into e.g. spatial coverages of various standard indicators, like Agricultural Landscape Diversity Index, or standard landscape metrics, which can be very easily computed by means of a pseudo-raster statistical grid (I tested it myself), but sometimes extremely complicated to obtain by standard computing methods (e.g. Fragstats software).

One of the most valuable features of the HIRIS system would be its open and flexible thematic structure, which would allow fast and relatively easy transition from one client-defined type of analytical work-flow to another, utilizing all the information already available in the system. Yet an even more important precondition is that the entire HIRIS infrastructure indeed perfectly suits the conceptual design of an open architecture multi-processing distributed database with a hierarchical user's access and WMS/WFS capabilities. This means that we are talking about a dynamic and flexible information system, distributed over a range of processing centres and servers, each of them responsible for a certain geographic region or thematics, yet all capable of interactive and extremely efficient exchange of attribute information and perfectly compatible because of a unique HIRIS_ID geo-locators and centralized meta-database. Such a platform would bridge the gap between highly innovative GMES products and a broad institutional users community, allowing the development of a broad range of on-line information services as a follow-up of GMES products. Also that would be one of the true operational elements of the INSPIRE initiative.

After implementation and operational testing of the HIRIS system on GIS data covering the Baltic Sea region and the whole of Europe, which will include development and testing of automated geo-processing routines, on-line meta-data service and data manipulation/visualization interfaces, the HIRIS concept could be further extended towards global coverage with the corresponding shift of coordinate reference system from ETRS89_LAEA to UTM or some other alternative offering a Global coverage.

Application of the RGB-Clustering Method for Automated Production of Thematic Land Cover Datasets

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Landscape structure and diversity are critical factors for the quality and diversity of biocenoses, therefore application of standard methods for rapid extraction of specific land cover thematic information from satellite images is essential for mapping the landscape structures and identification of the ongoing changes in the study area.

The main techniques involved in our studies were photo-interpretation of orthophoto data, masking and visual analysis of indicative false colour composites of LANDSAT ETM images, which enabled us to extract the core areas containing the land cover classes of interest (in most cases - macrophyte communities). Spatial enhancement of satellite data and the application of RGB clustering techniques produced thematic raster maps, which were further calibrated during an iterative quality control process by comparison with high-resolution imagery, field-checking and analysis of the available in-situ data samples. Recoding and statistical cleaning of calibrated thematic raster datasets produced final maps of spatial distribution of the major phytocenoses containing macrophyte communities, as well as statistical tables of their coverage in different sectors of the study area.

Results of our study proved the advantage of multispectral satellite imagery against the conventional high resolution optical data sources or field sampling methods for the purposes of rapid medium-scale mapping and statistical assessment of homogeneous communities of vegetation. Medium-sized (~30 m) pixels of satellite imagery provide a certain level of generalization, eliminating small details, which often complicate semi-automatic classification procedures by introducing a large amount of mixels (mixed pixels), whereas infrared spectral bands make it possible to construct false colour composites emphasizing different vegetation types, as well as soil and moisture conditions of the environment. However, in certain cases more detailed results can be achieved by applying pan-sharpening methods to the satellite images before running the RGB-clustering procedure. Even though pan-sharpening of satellite data is not recommended for running further spectral analysis, we found that in many cases RGB-clustering of pan-sharpened LANDSAT ETM images provide good results, but more careful ground quality control is needed to properly define thematic classes available in the more detailed raster dataset produced from pan-sharpened images.

The RGB clustering method provides obvious advantages against conventional supervised classification methods, as it is based on computation of statistical differences between spectral signatures of pixels within an 8 bit colour space making it possible to identify up to 255 different colour classes. It is therefore possible to carry out a rather simple iterative calibration of the classification results by masking out unnecessary areas, instead of manual sampling of homogeneous colour classes of interest, valid only for the given satellite image and practically impossible to repeat by other independent researchers. In other words, RGB clustering procedures takes the user-specified RGB composite of the satellite image and does an automatic separation of visible colours into 255 distinct colour classes - just the same way as the human eye does it, but using 8-bit colour space instead of millions of colours separated by the human eye. So the analysis reduces a simplified, but statistically correct aggregation of the selected 3 spectral bands into one-band thematic raster, ready for immediate analysis and use for extraction of specific land cover types.

GEO BON and the 2010 Biodiversity Target

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In the e-conference introduction, Katalin Török noted that "new topics to be addressed by GEO BON, relevant to EPBRS, are to review and prioritize research and design decision-support systems that integrate monitoring with ecological modelling and forecasting". I comment here on some potential research needs relating to needed integration of decision-support systems, modelling, and forecasting – with a goal of effective monitoring for the 2010 biodiversity target. This context recalls an original motivation for GEO BON - to "develop and implement a biodiversity observation network that is spatially and topically prioritized...which can support the 2010 CBD target".

The GEO BON Concept Document (Andrefouet et al., 2008) refers to two forms of biodiversity monitoring:
1. Repeated in-situ measurements of selected components of biodiversity at selected locations, to get a time series for analyses,
2. Modelling of patterns in the spatial distribution of biodiversity, using biotic/abiotic observations, unconstrained by time/place, and then using these models as a "lens" to interpret remotely-sensed changes in ecosystem condition and other key drivers.

The first approach has been considered a primary strategy for addressing 2010, but the second approach can take good advantage of biodiversity models, decision-support, and forecasting – and side-step some of the difficulties in obtaining broad-coverage time-series data for biodiversity.

First, we need effective biodiversity spatial modelling approaches that can add value to primary biotic observations (such as those from GBIF) through integration with key environmental variables. The rationale is that the integration of many species and environmental variables reveals underlying patterns of turnover that will be common to many species, so providing a way to address overall, wholesale, biodiversity. Arguably, GEO BON needs models that attempt inferences at this level in order to claim to be a biodiversity monitoring network in the broadest sense. Such models would use observations from a wide set of participants – demonstrating that the fundamental biodiversity "observations" of GEO BON can be very inclusive – covering many taxa, in many places, including old observations from museum collections. Additional data should permit continuous refinement of the models.

While the models are not static, they do not have to provide the critical times series for monitoring. The key temporal dimension could be produced through ongoing observations (provided through other parts of GEOSS) of changes in land cover, ecosystem condition, climate, etc, typically derived from remote sensing. Research is needed to enable better estimates of land condition, and to support the interpretation of these observations through the lens provided by the biodiversity models.

Naturally, this also should allow for consideration of possible future scenarios of change in those driving factors, and not just actual observed changes. For example, by using the biodiversity models as the lens to interpret alternative land condition futures, the approach could show how well-targeted conservation efforts may provide better land condition in critical places, resulting in a reduced rate of biodiversity loss. This link between models, decision-support, forecasting, and the 2010 target was discussed in a past BioStrat e-conference “How to reach the 2010-and beyond- target: research influencing policy” in the contribution, “Systematic Conservation Planning” (http://www.nbu.ac.uk/biota/Archive_2010target/8217.htm).

This strategy now also links to a GBIF Campaign on the 2010 target (see http://www.eurekalert.org/pub_releases/2008-02/gbif-fgc020708.php), which explores scenarios contrasting systematic conservation planning with "business as usual". Research and case studies are needed to test the hypothesis that the difficult 2010 target can be reached by any country willing to take-up and implement systematic conservation planning.

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Addendum

Integrating Monitoring Activities in the Real World

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According to the objectives of the Russian National Platform on biodiversity (http://bio.1september.ru/2004/28/5.htm) GIS technology is ensuring collection, storage, processing, analysis and continual upgrading of electronic maps for objectives of biodiversity control, and creating necessary conditions for successful biodiversity systematization, development of thematic maps and their further use. Priorities in this field are connected with the development of natural protected territories cadastres, distribution of endangered species, ecological education and knowledge dissemination for increasing of public activity e.t.c.

The main objectives are:
- to determine the scale of ecological threat in keystone regions
- to identify the most important geographic areas and habitats that need to be conserved
- to identify the major threats and to propose mitigating measures and prioritize conservation actions
- to develop an expert network focused on important ecological questions on biodiversity loss
- to target and address the highest conservation priorities.

For that purpose it is necessary for the extensive use of world experience using a variety of GIS technologies and the implementation of corresponding software. These actions are impossible without extensive international cooperation.

Russian scientists participate in many GIS projects, such as:
"Index Herbariorum" http://herba.msu.ru/russian/index.html,
"Global Amphibian Assessment" http://www.globalamphibians.org/partners.htm

Russia has national divisions of many international information systems such as UNEP-INFOTERRA. A national centre (http://refia.ru/) that publicises work of national nature protection systems, rights of the citizens and public organizations of the necessary and authentic information on environmental conditions and measures for its protection.

Any action in the field of forest fire prevention is impossible without GIS systems (http://www.rinya.maff.go.jp/mpci/rep-pub/2003/RussiaR) because of the huge scale of the Siberian and Far East forests. GIS data on biodiversity in Russia now includes genetic engineering (http://www.iacgea.ru/), agricultural biological resources (http://www.vir.nw.ru/), Zoological Institute (ZIN RAN) collections (http://www.zin.ru/), and public organizations such as Biodiveristy Conservation Centre of Social Ecological Union (http://www.biodiversity.ru/about/history.htm). To get information on a scale of GIS application in biodiversity conservation in Russia it is possible to use the web magazine "ArcReview" (http://www.dataplus.ru/Arcrev/Number_39/Index.html). It is possible to say that Russia now has full-scale involvement in world online activity on problems of biodiversity loss and its conservation that agree with the GEO BON concept.

Only in the GEF project "Biodiversity conservation" were the following executed: information bio-monitoring systems and the largest Russian environmental Web-portal BioDat.ru (http://biodat.ru/), which has united all information resources of the project and now serves as the national centre of a biodiversity data network; multi-user system, network of qualified manufacturers and users of biodiversity information. Large databases and GIS were generated on BioDat.ru, which are capable of promoting monitoring of biodiversity in the country; analysis and preparation of information for applied nature protection purposes was organized, including the supply of information of the Ministry of Natural Resources activities and other ministries and agencies in the field of biodiversity conservation; a module of information systems devoted to protected natural areas of Russia was also generated. The total number of information products prepared under this project is about 700; about one and a half thousand information resources are placed on the created portal BioDat.ru.

I agree with Klaus Henle's opinion that one of the problems is attracting volunteers for biodiversity monitoring in Russia via web systems. It directly depends on the social activity of the people and their well-being, so we hope that this process can have positive dynamics now. It is evident that the integrity of online biodiversity systems is increasing day by day, and we have to use any possibility to involve scientific supervising and analysis of new information conglomeration to direct it's development in the most optimal, coordinated and fruitful way.

Coordination of monitoring and monitoring data flow need to be improved

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There are two general aims of monitoring. Firstly, it is an idealistic search for knowledge about what is the fat e the biodiversity. Secondly, it is a more practical approach to collect information that can be used to examine the outcomes of management actions and to guide management decisions. It is widely acknowledged that current capability of researchers even in collaboration with large number of volunteers is insufficient to provide enough information for the first aim. Hence, there is a large need to simplify the approach and to find an adequate trade-off between precision of the biodiversity estimates and the effort needed for collection and analysis of data.
While reaching the second aim is much more feasible, it appears that even this one is largely not followed.

Recent analysis of plant monitoring schemes (Kull et al. 2008) has shown that there is a large dicrepancy between the aims of monitoring and actual activities. In EU, even protected species are often not monitored. Moreover, the monitoring that has been conducted largely does not en d up being published. The authors argue for several simple solutions that could have large positive impact on the knowledge about the status of biodiversity. I will utilise their conclusions and append to these.

1) There should be a conscious effort made to make all monitoring data publicly available. There have been and still are many journals which publish florstic and faunistic data, but their importance has diminished. Current development of internet, however, would enable for web-based solutions. GBIF aims at this, but their efforts should be more strongly supported. A much simpler approach would be local or regional. In Estonia, for example, Estonian Naturalists' Society and Estonian Environment Information Centre have compiled and maintain a public database of biodiversity (http://www.elus.ee/?levelID=5). Besides collection of information, efforts like this can be used to involve volunteers and to promote nature education.

2) The analysis of monitoring data is generally weak. Extrapolations from population level (where monitoring happens) to national or even wider levels are mostly absent. Yet, there are statistical tools available (e.g meta-analysis). It would be possible to automate the analysis of data if the data transfer were organised through a web portal as suggested above. Such system would also enable for instant demonstration of results (e.g. dynamics of a population or distribution of a species).

3) While monitoring mostly concentrates on population-level traits, it could be more useful for the general estimation of the trends of biodiversity to utilise mapping methods. Another recent publication (Sammul et al. 2008) has used such data and has shown how country-wide mapping of plants, when combined with indicative qualities of species, can yield ecological conclusions. Obviously mapping projects can not prov ide contiuous data and instant updates, but for most species that is not even needed. For evaluation of the fate of common species, mapping could be the only adequate approach.

4) The selection of species for monitoring needs to follow clear rationale. Preference should be given to species with indicative qualities of species. International coordination of selection of species should be considered. Scientific community could provide criteria for selection of species for monitoring that would enable evaluation of global dynamics of species.

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