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The European Biodiversity Observation Network - EBONE

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Abstract: EBONE (European Biodiversity Observation Network) is a project developing a system of biodiversity observation at regional, national and European levels as a contribution to European reporting on biodiversity. The project focuses on GEO (Group of Earth Observations) task BI 07-01 to unify many of the disparate biodiversity observing systems and creates a platform to integrate biodiversity data with other types of information. The system will make use of existing networks of site observations, wider countryside mapping and Earth observation (EO). The project addresses issues important for development of biodiversity monitoring system such as concept of monitoring; indicator species and habitats, in-situ and EO methods of biodiversity; database management and IT tools; protocols and harmonisation of available in-situ data. Special attention is paid to intercalibration of in-situ and EO monitoring. The system, methods and protocols developed in the project will be tested and validated in the field. Based on the validation we will propose refinements to the system (sites, protocols). The project aims to contribute to a world-wide monitoring system by developing a prototype system for monitoring Mediterranean ecosystems outside Europe. Because the project addresses a quite broad range of stakeholders, stakeholders will be involved in the design, development and testing of the monitoring system. The main outcome will be an integrated monitoring system based on key biodiversity indicators and implementation within an institutional framework operating at the European level.

Keywords: Biodiversity observation, GEOSS, GEO-BON, FP7 project, Monitoring harmonization, Information system

1. INTRODUCTION

Measuring and reporting reliably trends and changes in biodiversity requires that data and indicators are collected and analysed in a standardized and comparable way. This is valid for a national park, but also for larger areas such as the European Union. However at present all responsible authorities (over 100 national and regional authorities) have different and uncoordinated approaches. Globally, the problem is even worse, as species and ecosystems largely differ on the different continents. Therefore, there is a need to develop a system for a coherent system for data collection that can be used for international comparable assessments on an international scale.

EBONE is the Collaborative project of the 7th Framework Programme within theme 6 Environment (Topic 4.1.1.2. Contribution to a global biodiversity observation system). The EBONE project is developing a system of biodiversity observation at regional, national and European levels as a contribution to European reporting on biodiversity as well as to the Global Environmental Observation System of Systems (GEOSS) tasks on biodiversity and ecosystems. EBONE assesses existing approaches on validity and applicability starting in Europe, expanding to regions in Africa and seeking cooperation with projects in other continents. The objective of EBONE is to deliver:

1. A sound scientific basis for the production of statistical estimates of stock and change of key indicators that can then be interpreted by policy makers responding to EU Directives regarding threatened ecosystems and species;
2. The development of a system for estimating past changes and forecasting and testing policy options and management strategies for threatened ecosystems and species.
3. A proposal for a cost-effective biodiversity monitoring system in close collaboration with the major agencies and NGOs, that will be responsible for monitoring in the future.

This paper therefore deals with both technical and with organisational aspects.

2. EXISTING MONITORING PROGRAMS IN EUROPE

The information on running monitoring programs in Europe is based on an ongoing survey of biodiversity monitoring schemes in Europe, started by the EuMon project [EuMon 2009; see also http://eumon.ckff.si/) and continued in the EBIONE Project. The first results of that survey demonstrate that biodiversity monitoring is lacking a standardized approach in Europe, making it difficult to assess the state and trend of biodiversity across geographical and temporal scales from collected raw data [Schmeller 2008]. The EuMon survey is summarized in the online database DaEuMon [EuMon 2009] and allows to draw a detailed picture of monitoring practices in European species and habitat monitoring [Henry et al. 2008; Kull et al. 2008; Lengyel et al. 2008; Schmeller 2008; Schmeller et al. 2008]. Biodiversity monitoring in Europe encompasses a great diversity of different habitat and species monitoring programs. They vary among others in sampling effort, methodology (Figure 1), involvement of volunteers, incentives, and geographical scope. Half of all habitat monitoring schemes (here a monitoring program may encompass various monitoring schemes for different species or habitats) are of local scale (50%), followed by regional (28%) and national (18%) scale. For species it is the opposite, with schemes on a national scale making up 42% of all schemes followed by regional (27%) and local (25%) schemes. Only 0.6% (habitats) or 1.6% (species) and 2.4% (habitats) or 2.7% (species) of the assessed monitoring schemes cover the EU or are of international scale, respectively. Generally monitoring schemes were implemented due to scientific interest (31%), EU directives (21%), management or restoration (20%) or national obligations (17%). The support of volunteers is generally higher in species schemes (86% of all persons involved, see also [Schmeller 2008] and references cited therein) than in habitat schemes (9% of all persons involved) [Eumon 2009]. For habitats and species sampling effort varies greatly across spatial and temporal scales [Lengyel et al. 2008; Schmeller et al. 2008; EuMon 2009].

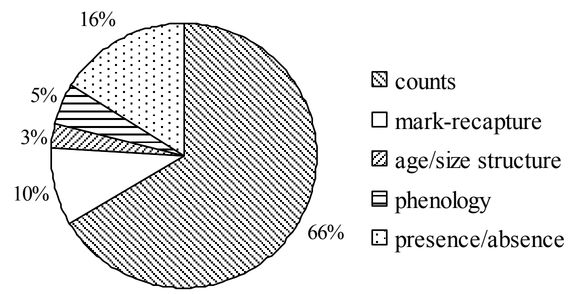

Figure 1. Monitoring methods used in species schemes. Source: EuMon Database on European Monitoring Schemes, February 2009, http://eumon.ckff.si/

According to the EuMon database, birds are by far the best represented species group in monitoring programs followed by mammals and invertebrates (Figure 2). Monitoring of birds is largely coordinated by BirdLife International and its partner organizations within the European countries [BirdLife International 2004]. Alongside the birds monitoring also the butterfly monitoring in Europe [van Swaay et al. 2008] might provide a good blueprint for the establishment of monitoring networks for other groups across Europe [Gregory et al. 2005; European Environment Agency 2007]. Butterfly monitoring schemes assess regional and national trends in butterfly abundance per species, and form a network among regional and national coordinators in different countries [van Swaay et al. 2008].
For European habitats and species the EuMon survey demonstrates that monitoring needs to improve with regard to spatial coverage, assessment of spatial variation, sampling design and data analysis. Without these improvements monitoring data will not be able to present an unbiased and realistic picture of the state of Europe's biodiversity that is necessary to measure the progress towards halting the loss of biodiversity by 2010 [Lengyel et al. 2008].

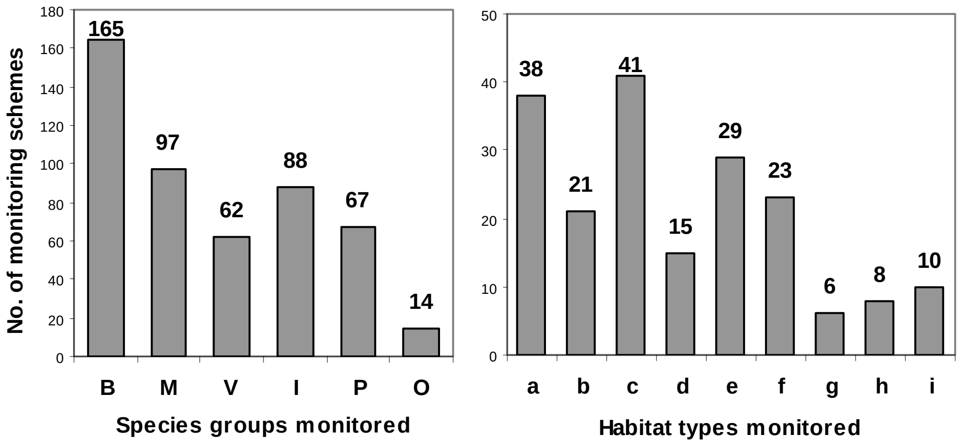

Figure 2. Number of monitoring schemes per species group and per habitat types in Europe. B – birds; M – Mammals; V – other Vertebrates; I – Invertebrates; P – plants; O – other; a - coastal and halophytic habitats; b - coastal sand dunes and inland dunes; c - forests; d - freshwater habitats; e - natural and semi-natural grasslands; f - raised bogs, mires and fens; g - rocky habitats and caves; h - sclerophyllous scrub; i - temperate heath and scrub. (Source: EuMon Database on European Monitoring Schemes, February 2009, http://eumon.ckff.si)

However, some of these improvements have already been implemented in three major international projects which are not included in the EUMON database:

1. The Countryside Survey of the United Kingdom [Haines-Young et al, 2000]. This survey has tracked habitat and vegetation changes from 1978 to 1984, 1990, 1998 and most recently 2007.The sample has increased from 256 1 km squares to over 600 at present. An extensive literature reports the results.
2. SISPARES [Ortega et al. 2008] is a series of over 200,16 square km units which have had aerial photograph interpretation over three dates since the 1960's to enable the assessment of habitat change in Spain.
2. The National Land Inventory of Sweden [Esseen et al. 2006] consists of a series of sites throughout Sweden with the objective of assessing habitats and vegetation for the whole country and eventually, the changes that are taking place.

All these projects are at a national level and are based on stratified random sampling to ensure that statistical estimates of habitat extent and spatial distribution can be achieved.

3. EBONE PROJECT

3. 1 EBONE concept

Whereas a considerable number of monitoring activities have been developed in response to the decline of biodiversity, existing monitoring schemes cover only specific elements of biodiversity, have a restricted geographical coverage, and may have limitations regarding the potential for spatial interpolation and generalisation or run only for a few years. The limited data that have currently been collected systematically can only enable restricted statistically reliable conclusions to be drawn. However, for Europe-wide monitoring and reporting the incorporation of further data are essential to extend the range of systems to be covered.

The project is designed to respond to the widely recognised problem of limitations in the linkage among existing monitoring systems, databases and monitoring sites. The key challenge that needs to be addressed is the cost effective data collection system for biodiversity linked with extant data, both past and present, at national, regional and European levels. This monitoring framework should cover all aspects of biodiversity in one coherent system. A systematic monitoring approach for Europe 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. Because cost-effectiveness belongs to the crucial aspects of monitoring systems, is also foreseen to include an assessment of the time and costs involved.

It is essential that the scientific basis is linked to a sound institutional framework to ensure continuity and long-term collaboration between partners who have a history of successful cooperation. The project includes facilitation of an institutional cooperation in a stratification system, nomenclature and data to be collected and agreements on database structure. The present project is based on a tried and tested network of partner institutes that have collaborated over many years and that have been monitoring change at a variety of scales. This network is open for other partners as well.

The strength of the approach is that it builds on all knowledge and networks developed in recent European projects such as ALTERNET, BioHab, BioPress, BioScore, Ecochange and EuMon. It makes use of existing LTER monitoring sites; it assesses their representativeness and includes the existing national monitoring systems. It will lead to a cost effective procedure for biodiversity monitoring by applying the most efficient indicators in a well balanced sampling programme.

3.2 EBONE implementation

The first phase of the project is to develop a conceptual framework for monitoring utilising the existing institutional context of European monitoring, databases, observation points and observing organizations agencies, and NGOs. The criteria for identifying indicators will be defined using existing experience and the framework of the CBD and SEBI and going beyond if needed. The design of requirements, protocols and procedures for a cost-effective monitoring system for Europe requires bringing together existing knowledge on monitoring protocols and a concept that is able to upscale and downscale data and observations from point locations to a general European level. It also needs a concept of the sampling design that can be used to test the existing data, observation points and databases. The conceptual framework will be used to consider how monitoring of biodiversity trends can be linked with the ecosystem research on underlying processes, drivers and pressures at multiple scales.

We will prepare an overview of the characteristics of the existing larger monitoring and surveillance systems in Europe and a link between the methods, data and observation sites available in different countries and regions as well as with various ongoing projects, available databases and observation and monitoring systems. We will determine the relationship between National Responsibilities (NR) and Conservation Priorities (CP) of species and habitats with monitoring systems. A proposal will be made for the best way to include different monitoring systems into a European strategy that includes NRs and CPs and develop an approach for a global biodiversity observation system.

The statistically robust framework for monitoring is under development and it will form the basis for a system for Europe-wide statistically reliable, geographically referenced and comparable data collection of species and habitats of conservation interest. The existing knowledge on monitoring protocols will be used for harmonization of protocols for different

species groups and habitats. The General Habitat Categories of the BioHab project will be used as a common denominator to link existing data sets. The special attention will be paid to intercalibration of Earth observation (EO) and in-situ monitoring data (see chapter 4). The monitoring system will be validated and the cost aspects in time and budget will be monitored in representative test sites. The sample sites in the project will be dispersed in strata defined in the project of the European Environmental Stratification [Jongman et al 2006]. One of the important steps is to carry out tests on the data from LTER (Long-Term Ecological Research) sites in relation with data from nation-wide habitat monitoring programmes. We will also adapt the system developed for Europe into Mediterranean systems in test areas in Israel and South Africa as representative countries for this biogeographical zone (see chapter 5.3). The institutional arrangements and the cost effectiveness of a proposed surveillance and monitoring system will be evaluated and the results will be used to design a management procedure for a time- and cost efficient monitoring system.

The data management represents an important aspect of the monitoring system developing by the project; the main challenge is to provide common database access across all types of data supplied by diverse sources and in varying granularity, ranging from remote sensing data over national monitoring networks to the very dense and detailed data supplied by the LTER sites and LTSER platforms.

In all stages of the project stakeholder involvement is required; important is the communication to agencies institutions, managers of databases and organisations that already carry out established European-wide and countrywide monitoring systems. These stakeholders will be involved to the monitoring system development, its testing and improvement and also training of stakeholders in monitoring using system developed in the EBONE project is foreseen. The communication with international, national and regional responsible bodies is the only way to get the system accepted and agreed upon.

4. EO OBSERVATION AND INTER-CALIBRATION WITH IN-SITU MONITORING

4.1 EO observation of land cover, habitats and species

EO instruments record reflected, scattered or emitted electromagnetic signals which vary in function of the physical and chemical properties of the viewed surface type. Two types of information can be derived from EO data (Figure3): quantitative measures of these physical or chemical properties (i.e. a map of for example soil moisture, surface temperature or canopy cover) or a map of thematic classes representing areas with similar reflected, scattered or emitted electromagnetic signals, texture, patterns or shapes. EO derived products of land cover, habitats and species (flora) belong to the second category.

The observation and recording of land cover, habitats and species require different classification systems. Their design results from a compromise between scope of use, level of detail and spatial application. EO introduces not only full area and frequent coverage, but also a new and unique set of classification parameters. The degree in which a relationship can be established between electromagnetic signals and the thematic classes (e.g. physiognomic, floristic or ecological) required by the biodiversity monitoring community, will determine the usefulness of the EO derived thematic maps. The work of Paradella et al. [1994] suggested that physiognomy may be the most important attribute which influences the EO response of vegetation. Whilst Jakubauskas et al. [2002], Moody and Johnson [2001] and Hill et al. [submitted] have reported successful crop, vegetation and species classifications when using time series of EO to exploit differences in phenology. Many have shown that when working regionally or locally, and using EO data types and classification approaches appropriate for the local scenario, accurate and reliable and therefore useful results can be achieved [Hill and Thomson 2005, Thomson et al 2003, Bock et al 2005]. However, when continental and global biodiversity monitoring requires consistency in methodology, the variety of EO data types and approaches available is greatly reduced. As a result, the global land cover maps produced from EO have been limited to reporting the extent of major vegetation types (total number of vegetation classes ranges between 7 and 18, Table 1) at pixel sizes ranging from 1km to 300m. The class number and type and the spatial detail of these products make them inadequate for detailed biodiversity or habitat monitoring.

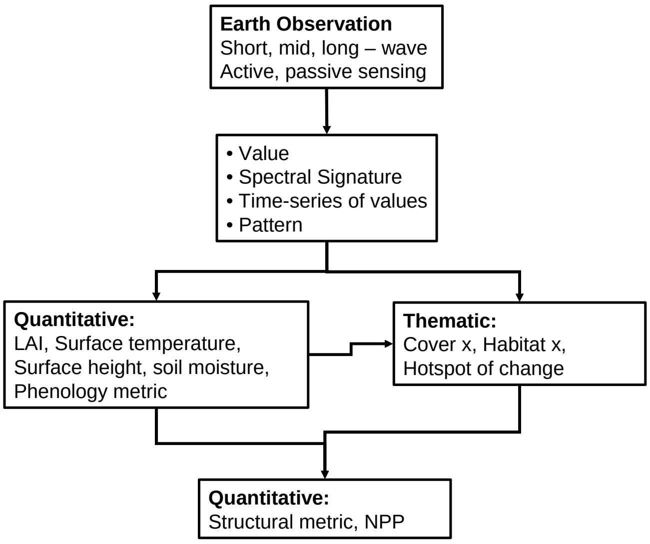

Figure 3. Schematic illustrating the difference between the quantitative and thematic measures derived from Earth Observation.

In addition to thematic maps, EO can deliver quantitative information that is related to site conditions, physiological processes, stress conditions or vegetation damage, and is relevant to biodiversity. For example, the leaf phenological cycle and its changes over time have been measured with EO [Delbart et al. 2006, Heumann et al. 2007], the SEBI indicator 'fragmentation' is an obvious candidate for EO retrieval [Estreguil et al., submitted], and EO vegetation indices have been related to NPP and linked to species richness [Oindo and Skidmore 2002].

Table 1: Global Land cover maps derived from EO currently available

Land cover map	Pixel size	Total N° classes	N° vegetation (arable) classes
IGBP [Loveland and Belward, 1997]	1 km	17	12(2)
GLC2000 [Bartholome and Belward, 2005]	1 km	22	18(3)
MOD12Q1 PFT [Friedl et al., 2002]	1km	11	7(2)
GLOBCOVER [Arino et al., 2005]	300 m	22	14 (4)

'Going in situ' is the only way to collect detailed information on the flora and fauna present. Also in situ land cover or habitat observations, when benefiting from a well designed field survey approach and protocol, have the advantage of providing high thematic and spatial detail. In both cases, in situ work is intensive and costly and is therefore limited in the area it can cover and the revisit frequency, and although the spatial detail of the area outlines identified can be high, they often vary with surveyor, especially in areas containing soft gradients rather than hard boundaries.

4.2 Inter-calibration of EO and in-situ monitoring

In the context of biodiversity monitoring, the idea of integrating in situ with EO is that the combination of the two data set types will deliver more accurate or reliable information on biodiversity than either of the two data sets used independently. EO can take on different roles when it is considered for enhancing in situ observations. It can be used as a vehicle for interpolation and generalisation by delivering full coverage, or it could be used to increase the number of in situ samples in space and time. Here, the key for success is a good link between the EO derived thematic map and the in situ habitat observations. EO could also be used to search for and highlight hotspot areas of sudden or gradual change, or to provide context where it delivers additional information on, for example, land cover composition, landscape structure or phenology, complementing the in situ species and habitat data. In all cases the concept of linking EO derived information with field data to enhance observations on biodiversity is based on the premises that a relationship exists between the composition and structure of the landscape and the diversity of habitats and the species and genotypes that may be present within.

Many trials have already been carried out, and although much discussed, full integration between in situ and EO has not been achieved, as emphasised in the recent GMES summary produced by Wyatt et al [2004]. The BIOPRESS project [Köhler et al 2006] and the PEENHAB project [Mücher et al. 2004] whilst using the state of the art data bases for predicting habitats, show that all the available data bases have limitations and restrictions because of lack of validation. EBONE is planning to provide clear statements on the added value of data integration by testing if integration delivers improved estimates of biodiversity measures, in particular the SEBI indicators: (i) Trends in extent of selected ecosystems and habitats and (ii) Trends in abundance and distribution of selected species.

One main element of the work will investigate an approach developed by Fuller et al [1998] for the UK which is referred to as 'inter-calibration'. Inter-calibration is particularly suited for the SEBI indicator 'Trends in extent of habitats'. Inter-calibration uses correspondence matrices [Lillesand and Kiefer, 1994] that are created to calculate the classification accuracy of EO derived land cover maps, to produce stratum specific calibration matrices (i.e the calibration matrices are a weighted average of the correspondence matrices produced for in situ sample sites located within an environmental stratum). These calibration matrices are then used to alter the original land cover percentages and classes of the EO derived map to better match the habitat classes and their cover percentages observed in the field (Figure 4). Although this reduces the original spatial resolution of the land cover map from 25 m to 1 km, Fuller et al [1998] found that,

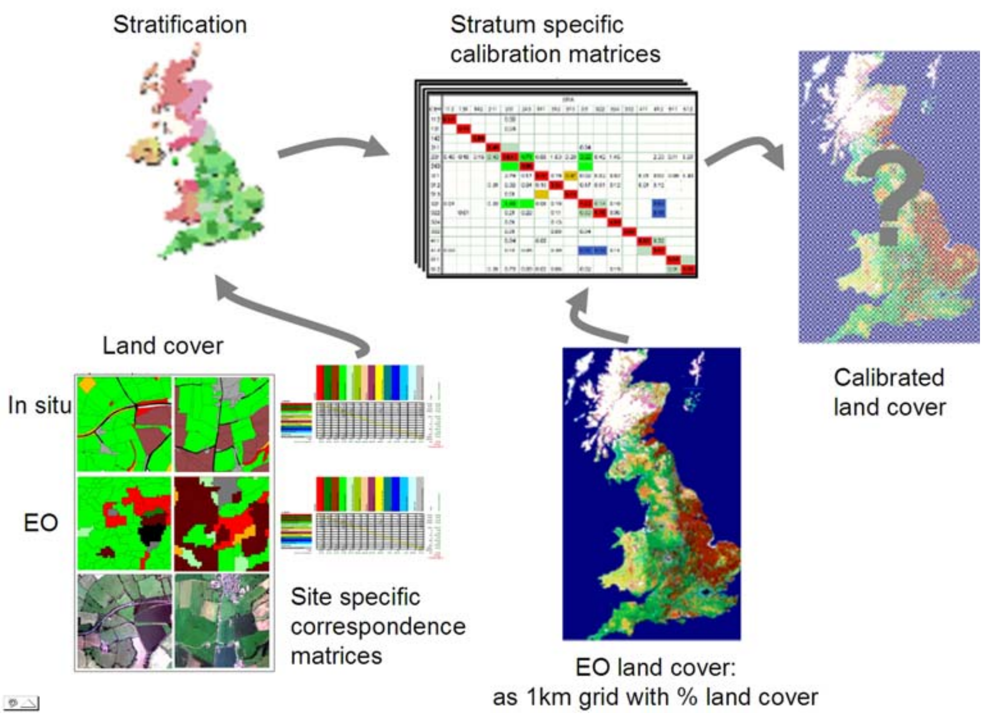

Figure 4. Diagram illustrating inter-calibration as implemented by Fuller et al (1998)

at national level, the habitat statistics produced from the calibrated land cover map closely matched those extrapolated from the field samples. More importantly regional habitat estimates made from the calibrated land cover map showed tighter confidence limits than those acquired from the field survey samples.

The EBONE hypothesis is that better estimates of habitat extent can be achieved through inter-calibration when combined with a well designed environmental stratification [Jongman et al. 2006] and a habitat classification system such as the BioHab General Habitat Categories (GHC) system which is based on 'EO friendly' physiognomic characteristics. EBONE will investigate the success of inter-calibration applied on existing EO land cover maps which provide full coverage but also look at the inter-calibration of EO habitat maps of sample sites produced to increase the in situ samples in space and/or time. The advantage of the second approach is that it could allow for the introduction of strata specific EO mapping methods. In this context EBONE will look at the role of LIDAR and EO time-series analysis.

Species distribution models that incorporate in situ and EO derived information is another form of integration that could potentially deliver improved measures of the SEBI indicator 'Trends in abundance and distribution of selected species' [Gillespie et al. 2008]. Here both thematic (land cover maps calibrated to GHC observations) and quantitative EO derived information such as fragmentation and phenology metrics will be considered. One caveat is that distribution models highlight areas with high probabilities of a specific species occurring which does not necessarily mean the species in question will be found in all of the areas identified.

5. EBONE CONTRIBUTION TO EUROPEAN AND WORLD-WIDE PROGRAMS

5.1. GEO and GEO-BON

The Group on Earth Observations or GEO (www.earthobservations.org) is a partnership of 76 member nations and more than 50 NGOs, working to benefit society by improving the coordination of existing Earth observation data sets and implementing new observations and related products. It is designing a Global Earth Observing System of Systems (GEOSS) as the mechanism to achieve these goals. Biodiversity is one of the nine Societal Benefit Areas set forth by GEO as foci for its work. Thus, a Biodiversity Observation Network (GEO BON) is one of the first systems GEO is proposing for the GEOSS.

By facilitating and linking efforts of countries, international organizations, and individuals, GEO BON will contribute to the collection, management, sharing, and analysis of data on the status and trends of the world's biodiversity. It will also identify gaps in existing observation systems and promote mechanisms to fill them. The role of EBONE in this context is to act as a pilot for Europe that can be used by comparable initiatives in other continents.

The scope of GEO BON includes the terrestrial, freshwater, coastal, and open ocean marine components of biodiversity. Its definition of biodiversity encompasses genetic, species and ecosystem levels. In addition to collecting time series of observations on the presence, abundance and condition of elements of biodiversity at all of these levels, it will conduct limited analyses, such as change detection, trend analyses, forward projections, range interpolations and model-based estimations of the supply of ecosystem services. It will act in support of more detailed assessments undertaken by biodiversity and ecosystem assessment bodies. EBONE focuses on the terrestrial environment and an additional initiative for the marine environment is very much wanted.

The main users of GEO BON will likely be national governments (especially in relation to their obligations under biodiversity-related conventions) and their natural resource and biodiversity conservation agencies at national and regional levels, 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.

The EBONE project is the European contribution to GEO BON. It is developing a system of biodiversity observation at regional, national and European levels as a contribution to European reporting on biodiversity as well as to the GEOSS tasks on biodiversity and ecosystems. EBONE assesses existing approaches on validity and applicability starting in Europe, expanding to regions in Africa and seeking cooperation with projects in other continents.

5.2. LIFE-Watch

LifeWatch is an integrated approach for developing an advanced infrastructure for biodiversity research using a wide range of techniques. It will be significant in tackling one of the major challenges facing modern society, bringing together many disciplines and investigative techniques, all at the cutting edge of research, and will be how much research is done in the future. It intends to make massive biodiversity data sets available, searchable through an user interfaces; tens of thousands of users exploring these data and joining forces in virtual user groups. It also intends to give access to scientists and policy makers comparing and supplementing these data with even more data obtained from weather stations, satellites, biological collections from all over Europe.

The contribution that EBONE can provide to LifeWatch is the development of a ready available system for observation and data storage; not only for species, but also for habitats and supporting earth observation.

5.3. Extension of EBONE approach to Mediterranean regions outside Europe

The EBONE approach for Europe will need to be compatible with approaches at the world-wide level. Through a pilot for global Mediterranean systems EBONE will adapt the system that will be developed for Europe for Mediterranean and desert systems in test areas in Israel and South Africa as representative countries for this biogeographical zone. This allows linking European approaches to Mediterranean and desert environment elsewhere in the world and allows testing of the methodology. A fundamental feature of the common approach to habitats is that it is based on life forms that form a biogeographical basis for defining word biomes.

Within the EBONE project, two partners focus on Mediterranean-desert gradients, one in Israel and one in South Africa. CSIR, the South African partner, works from an existing Biota-Africa regional network similar to the LTER system, in which research stations are positioned regularly along the western coast of South Africa and into Namibia (see www.biota-africa.de). In this system there is heavy emphasis on remote sensing and detailed in situ biodiversity studies; the habitat mapping used in EBONE bridges a gap in this system.

In contrast, the Israeli partner INPA is focused on conservation management at the habitat level, and has great interest in effective habitat mapping. INPA and its partners in the Israel LTER system also have several research stations along a rainfall gradient from Mediterranean to desert regions. The stations are linked by a common protocol for monitoring the response to thinning and grazing by different groups of organisms in a statistically valid experimental block design, but some have additional studies as well.

Two of these stations are currently in use for testing EBONE methodology and field work is ongoing; one in desert at the Avdat LTER site in the Negev Highlands, and the other in Mediterranean forest and maquis at Ramat HaNadiv near Mt. Carmel (see http://aristo4bgu.bgu.ac.il/maarag/Default.aspx for details on these LTER sites). Orthophoto coverage is used in all the Israel LTER sites, and coverage is good for the country. Ramat HaNadiv is a well established research site, and has an extensive monitoring program for plants, vertebrates, invertebrates, and geochemistry in place, while Avdat is a recently established LTER site mainly with information on plants and invertebrates.

Deserts are outside the range of European habitats, so the methods and descriptors of habitats have to be modified somewhat for use in Israel. During the past year, we worked to develop these adaptations, which are currently being tested in the field by survey of five test squares in Avdat and five in Ramat HaNadiv.

Two workshops and field exercises have been held in the past year to introduce and train Israeli scientists in the use of the BioHab habitat mapping system used in EBONE. There is strong interest among Israeli conservation organizations to develop and use a standardized habitat mapping system which enables sharing of data, so the pool of participants in this training has been drawn from conservation, forestry, rangeland, and basic ecological research organizations. There is developing consensus among these organizations that, with a little adaptation, BioHab may suit our needs and be implemented nationwide in Israel. A third workshop is planned for November 2009, in which the results of the current habitat mapping experiments will be reported, and the range of interest will expand to the EO and biodiversity monitoring methodology used in EBONE.

The unified habitat mapping methodology system is well under development in Israel, with discussion and adaptation now taking place daily. EO methods do not yet seem problematic. The weak part of our work is the biodiversity methodology. We need to determine which measures of biodiversity are most meaningful and how these may be linked to habitat and EO data. We have introduced the SEBI2010 program to the INPA and to the Israel LTER for consideration as a framework for biodiversity monitoring and this is currently under consideration. EBONE also works with the SEBI2010 biodiversity indicators, so we may be able to move forward in parallel.

6. CONCLUSIONS

The main outcome of the project will be an integrated monitoring system based on key biodiversity indicators and implementation within an institutional framework operating at the European level. This framework will provide continued access to indicator data for CBD reporting against the 2010 target and form the basis for the continued development of a European Biodiversity Observation system.

EBONE is a global pilot for international cooperation in biodiversity monitoring tackling the technical problems of harmonising approaches that differ in many ways:

- Topic: species, habitats and earth observation;
- Scale: from insects to migrating birds;
- Biogeography: linking Boreal, Mediterranean and Desert habitats and species;
- Organisation: trying to convince over 100 European agencies and an unknown number of NGOs to harmonise approaches.

This challenge has to be met for global reporting on biodiversity.

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REFERENCES

Bartholome, E., and A. Belward, GLC2000; a new approach to global land cover mapping from Earth Observation data, *International Journal of Remote Sensing*, 26, 1959-1977, 2005.

Bell, S., M. Marzano, J. Cent, H. Kobierska, D. Podjed, D. Vandzinskaite, H. Reinert, A. Armaitiene, M. Grodzińska-Jurczak, and R. Muršič, What counts? Volunteers and their organisations in the recording and monitoring of biodiversity. *Biodiversity Conservation,* 17, 3443-3454, 2008.

BirdLife International, Birds in the European Union: a status assessment. Wageningen, The Netherlands, BirdLife International, 2004.

Bock, M., P. Xofis, J. Mitchley, G. Rossner, and M. Wissen, Object-oriented methods for habitat mapping at multiple scales - Case studies from Northern Germany and Wye Downs, UK, *Journal for Nature Conservation,* 13, 75-89, 2005.

Delbart, N., T. Le Toan, L. Kergoat, and V. Fedotova, Remote sensing of spring phenology in boreal regions: A free of snow-effect method using NOAA-AVHRR and SPOT-VGT data (1982-2004), *Remote Sensing of Environment*, 101, 52-62, 2006.

Esseen, P.-A., A. Glimskär, G. Ståhl, and S. Sundquist, Field sampling protocol for National Inventory of Landscapes in Sweden (in Swedish). Dept. of Forest Resource Management, Swedish University of Agricultural Sciences, Umeå, 222 pp., 2006.

Estreguil, C., P. Vogt, and K. Ostapowicz, European level assessment of the status and trends of forest spatial patterns*, Environmental Monitoring and Assessment Journal,* submitted.

European Environment Agency, Halting the loss of biodiversity by 2010: proposal for a first set of indicators to monitor progress in Europe. Office for Official Publications of the European Communities, 2007. http://reports.eea.europa.eu.

EuMon, EU-wide monitoring methods and systems of surveillance for species and habitats of community interest, 2009. http://eumon.ckff.si/

Friedl, M.A., D.K. McIver, J.C.F. Hodges, X.Y. Zhang, D. Muchoney, A.H. Strahler, C.E. Woodcock, S. Gopal, A. Schneider, A. Cooper, A. Baccini, F. Gao, and C. Schaaf, Global land cover mapping from MODIS: algorithms and early results, *Remote Sensing of Environment*, 83, 287-302, 2002.

Gregory, R.D., A. van Strien, P. Vorisek, A.W. Gmelig Meyling, D.G. Noble, R.P.B. Foppen, and D.W. Gibbons, Developing indicators for European birds, *Philos Trans R Soc Lond Ser B Biol Sci,* 360, 269–288, 2005.

Gillespie, T., G. Foody, D. Rocchini, A. Giorgi, and S. Saatchi, Measuring and modelling biodiversity from space, *Progress in Physical Geography*, 32, 203-221, 2008.

Haines-Young, R.H., C.J. Barr, H.I.J. Black, D.J. Briggs, R.G.H. Bunce, R.T. Clarke, A. Cooper, F.H. Dawson, L.G. Firbank, R.M. Fuller, M.T. Furse, M.K. Gillespie, R. Hill, M. Hornung, D.C. Howard, T. McCann, M.D. Morecroft, S. Petit, A.R.J. Sier, S.M. Smart, G.M. Smith, A.P. Stott, R.C. Stuart, and J.W. Watkins, Accounting for nature: assessing habitats in the UK countryside, DETR, London, 2000.

Henry, P.-Y., S. Lengyel, P. Nowicki, R. Julliard, J. Clobert, T. Čelik, B. Gruber, D.S. Schmeller, V. Babij, and K. Henle, Integrating ongoing biodiversity monitoring: potential benefits and methods, *Biodiversity Conservation,* 17, 3357-3382, 2008.

Heumann B, Seaquist J, Eklundh L and Jonsson P (2007). AVHRR derived phenological change in the Sahel and Soudan, Africa, 1982–2005. *Remote Sensing of Environment*, 108, 385 – 392

Hovestadt, T., and P. Nowicki, Process and measurement errors of population size: Their mutual effects on precision and bias of estimates for demographic parameters, *Biodiversity Conservation,* 17, 3417-3429, 2008.

Hill, R., A. Wilson, and M. George, Mapping tree species in temperate deciduous woodland using time-series multi-spectral data, *Journal of Applied Vegetation Science,* submitted.

Hill, R., and A. Thomson, Mapping woodland species composition and structure using airborne spectral and LiDAR data*, International Journal of Remote Sensing*, 26, 3763–3777, 2005.

Jakubauskas, M., D. Legates, and J. Kastens, Crop identification using harmonic analysis of time-series AVHRR NDVI data, *Computers and Electronics in Agriculture*, 37, 127-139, 2002.

Jongman, R.H.G., R.H.G. Bunce, M.J. Metzger, C.A. Mucher, and D.C. Howard, A statistical Environmental Stratification of Europe: objectives and applications. *Landscape Ecology,* 21:409-419, 2006.

Jurczak, M., and R. Muršič, What counts? Volunteers and their organisations in the recording and monitoring of biodiversity, *Biodiversity Conservation,* 17, 3443-3454, 2008.

Kull, T., M. Sammul, K. Kull, K. Lanno, K. Tali., B. Gruber., D. Schmeller, K. Henle, Necessity and reality of monitoring threatened European vascular plants, *Biodiversity Conservation,* 17, 3383-3402, 2008.

Lengyel, S., E. Déri, Z. Varga, R. Horváth, B. Tóthmérész, P.-Y. Henry, A. Kobler, L. Kutnar, V. Babij, A. Seliškar, C. Christia, E. Papastergiadou, B. Gruber, and K. Henle, Habitat monitoring in Europe: a description of current practices, *Biodiversity Conservation* 17, 3327-3339, 2008.

Lengyel, S., A. Kobler, L. Kutnar, E. Framstad, P.-Y. Henry, V. Babij, B. Gruber, D. Schmeller, and K. Henle, A review and a framework for the integration of biodiversity monitoring at the habitat level, *Biodiversity Conservation,* 17, 3341-3356, 2008.

Lillesand, T., and R. Kiefer, Remote Sensing and Image Interpretation, Third Edition, John Wiley and Sons Inc., 1994.

Loveland, T.R., and A.S. Belward, The IGBP-DIS global 1km land cover data set, DISCover: first results, *International Journal of Remote Sensing*, 18, 3289-3295, 1997.

Moody, A., and D. Johnson, Land-surface phenologies from AVHRR using the discrete fourier transform, *Remote Sensing of Environment*, 75, 305-323, 2001.

Oindo, B., and A. Skidmore, Interannual variability of NDVI and species richness in Kenya*, International Journal of Remote Sensing*, 23, 205-298, 2002.

Ortega, M., R.G.H. Bunce, J.M. García del Barrio, and R. Elena-Rosselló, The relative dependence of Spanish landscape pattern on environmental and geographical variables over time. Investigación Agraria: Sistemas y Recursos Forestales, 2008.

Paradella, W., M. Da Silva, N. Rosa, and C. Kushigbor, A geobotanical approach to the tropical rain forest environment of the Carajas mineral province (Amazon region, Brazil), based on digital TM-Landsat and DEM data, *International Journal of Remote Sensing*, 15, 1633-1648, 1994.

Schmeller, D.S.,European species and habitat monitoring: where are we now? *Biodiversity Conservation,* 17, 3321-3326, 2008.

Schmeller, D.S., P.-Y. Henry, R. Julliard, B. Gruber, J. Clobert, F. Dziock, S. Lengyel, P. Nowicki, E. Deri, E. Budrys, T. Kull, K. Tali, B. Bauch, J. Settele, C. Van Sway, A. Kobler, V. Babij, E. Papastergiadou, and K. Henle, Advantages of volunteer-based biodiversity monitoring in Europe, *Conservation Biology*, 1523-1739, 2008.

Thomson, A., R. Fuller, M. Yates, S. Brown, R. Cox, and R. Wadsworth, The use of airborne remote sensing for extensive mapping of intertidal sediments and saltmarshes in eastern England, *International Journal of Remote Sensing*, 24, 2717–2737, 2003.

Van Swaay, C.A.M., P. Nowicki, J. Settele, amd A. Strien, Butterfly Monitoring in Europe -methods, applications and perspectives, *Biodiversity Conservation,* 17, 3455-3469, 2008.