Executive Summary:

The key challenge of the FP7 project European Biodiversity Observation Network (EBONE) is the development of a cost¬-effective system of biodiversity data collection at regional, national and European levels. The project aims to develop a system for a coherent system for data collection that can be used for international comparable assessments. It has set major steps in harmonisation of biodiversity observation in Europe. It has had its focus on habitat information and linking field observations with Remote Sensing. Its results are being applied already in on-going projects and as national approaches in Switzerland and Israel. Four major products are:

- The European Habitat Classification developed as General Habitat Categories for cost effective in situ habitat monitoring (e.g. for Habitats Directive reporting, Aichi targets) and linking existing approaches in Europe;
- The Global Environmental Stratification that provides a consistent stratification of the terrestrial parts of the globe in about 125 strata, that will allow cost efficient global biodiversity observation;
- A habitat database that allows sharing of European habitat and species data from new field observation, from existing surveys (such as the Swedish NILS survey and the British Countryside survey) for better and cost-effective European reporting;
- Remote sensing approaches such as LiDAR can be used for local habitat mapping and phenology indicators have been developed.

The General Habitat Categories (GHCs) have been developed and tested for Europe, and for non-European Mediterranean and desert environments, and have been successfully applied in field inventories and for linking Remote Sensing information with in situ data. For efficient field data collection an Access database has been developed for tablet PCs. The EBONE approach is now being tested for in situ monitoring at the national level in Switzerland and applied in Israel, in adaptation to the needs within these countries. Other FP7 projects are using the approach to collect basic field data (see the BioBio project, http://www.biobio-indicator.org, and BIO SOS, http://www.biosos.wur.nl/UK/).

Through work in Israel, South Africa and Australia a first step has been set towards global harmonisation by the extension of the GHC classification other biomes of the world. The GHC approach makes it possible to link in situ habitat data and Land Cover data globally, because the FAO Land Cover Classification System (LCCS) follows a comparable approach.

EBONE mapping is three times faster than traditional vegetation mapping methods; this allows researchers and agencies to decrease costs considerably. GHCs make it possible to correlate habitats with species composition as well as with several Remote Sensing (RS) categories.

In EBONE the European Environmental Stratification has been used to design a sample approach for Europe. This stratification that has been developed in 2005 in BioHab, the EBONE predecessor, is being applied in several European projects. EBONE explored how a sampling strategy can be developed for Europe in a rolling sampling system with coverage comparable to NILS in Sweden and the British Countryside Survey and its potential implementation costs. It is already in use in several global projects.

The GEO Portal and the data warehouse has been produced according to European standards according to the INSPIRE Directive and is based on a user requirement survey (164 replies). The result has also been included in the work of the INSPIRE TDWG Species Distribution, Habitats and Biogeographic Regions.

Results are being produced in the application of Remote Sensing for biodiversity observations. RS studies have been done by many partners and LiDAR has been tested in the Netherlands, Estonia, Slovakia and Israel. Reports on the use of LiDAR for biodiversity mapping and monitoring, the use of phenology indices and pattern related indicators are already available through the EBONE website.

EBONE has been instrumental for the Convention on Biological Diversity by organising the GEO BON workshop on the Assessment of Observation Capabilities for the Aichi targets. This report has been submitted to the AHTEC and has been positively received by the SBSTTA of the CBD. This workshop also initiated the process of discussing Essential Biodiversity Variables (EBVs) to be developed in a comparable process as the Essential Climate Variables (ECVs).

Project Context and Objectives:

The European Biodiversity Observation Network is a European contribution on terrestrial monitoring to GEO BON, the Group on Earth Observations Biodiversity Observation Network, the biodiversity Community of Practice of the Group on Earth Observations (GEO). The primary goal of GEO BON is to improve coordination among people and organizations collecting, managing, and utilizing biodiversity observations, thereby increasing the ability of others to access, share, and analyse these observations for reaching the objective of making the global community better informed on the stock and change in biodiversity.

GEO BON is developing two closely related, global networks, a social network for those engaged in collecting, managing, and utilizing biodiversity observations as well as and a network of interoperating systems that store and distribute biodiversity information of all kinds held by a great number of organizations. EBONE is a pilot for GEO BON developing elements of these networks in Europe and sharing the experience with other initiatives in Europe and the world.

European and international reporting and assessments on biodiversity are hampered lack of harmonisation: data used and the way they are collected and analysed is different for all countries and NGOs. Conclusions can therefore not be generalised as is done for other fields such as agriculture, health and climate. This project has initiated common approaches and harmonisation of data from both field observations and earth observations. It has assessed existing approaches on their validity and their applicability starting with Europe and it is expanding to other regions of the world. It has built on other European (FP5 and FP6) projects such as BIOHAB, BIOPRESS, EUMON and national project experiences such as the Countryside Survey (GB), NILS (Sweden) and HABISTAT (Flanders).

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. For the determination of indicators 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 project delivers the variables, a proposal on how they can be collected to fill these indicators consistently, analysis of the use of RS tools and a data warehouse for common storage of data.

However, biodiversity observations are among the most numerous and longest recorded observations of the environment. There are vast collections of plants and animals in museums and herbaria around the globe. One estimate suggests 2.3 billion such records (Suarez and Tsutsui, 2004); hundreds of millions of observations in the field by professional and lay experts; and terabytes of remotely sensed images and maps of the changing cover on the land surface (Scholes et al 2012).

The amount of existing biodiversity observations in Europe is very large; however, observations are also uneven in spatial, temporal, topical, and taxonomic coverage. Most monitoring organisations are based in north-western Europe and most data are available from the same region, while south-eastern and Mediterranean Europe have much less complete datasets. Additionally, observations exist in a variety of disparate formats, scattered among thousands of independent systems, often making them difficult or impossible to access, and hampering the ability to do global or regional assessments. Coordinating both the collection of biodiversity observations, as well as their storage, management, and distribution, would greatly increase the value of these observations by allowing much more value to be extracted from them. To complicate matters further, remotely sensed observations are often used to describe land cover and not ecosystems and time series of in situ data are mostly lacking. It is the purpose of EBONE to make data exchangeable so that they can be used in a coordinated way to make distribution maps, statistics on stock and change and wall-to-wall maps and in the end use these to populate the biodiversity indicators for the Convention on Biological Diversity (SBSTTA, 2011) and the European SEBI indicators (European Environmental Agency 2007).

A distinction has to be made between data collected for basic research such as for a research programme or a specific PhD project and data collected with the objective of applied research reporting on status and changes as obliged for national European and International obligations. Although data in fundamental research can be long term data and can have important data series they do not have to be part of a larger dataset and can be isolated with its own specifications. Basic research is project and interest driven; it mostly is looking for causes, relationships and explanation of fundamental problems such as causes of extinction in species populations (Den Boer 1977).

Applied research is policy driven and requires continuity for the assessment of policies and management practices or obligations for Directives and international Conventions. This means that monitoring activities need continuity in time; they should cover the major elements of value and should be exchangeable with other entities (agencies, governments, Non-Governmental Organisations) playing a role in biodiversity management and conservation.

In this project we develop the data needed and their harmonisation. We present the stratification that has been developed as this is important to include differences in distribution to be monitored. The next section will treat the way data can be compared and integrated across regions by using general habitat categories. Then the data architecture is treated, the clients and their data needs. The last section deals with the challenges that have to be dealt with in the European context.

Objectives

The objectives of the EBONE project are:

1. The provision of 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 change but also for forecasting and testing policy options and designing mitigating management strategies for threatened ecosystems and species.

The scientific basis of the project requires a sound institutional framework to ensure continuity and long term collaboration between partners in the project and beyond. The end product is therefore be intended to be a biodiversity observation network that is spatially and topically prioritized and a structure for an institutional framework allowing European and monitoring and a possible extension worldwide including projections on trends based on reliable data and indicators. This is elaborated in the following working objectives:

1. Elaboration of a monitoring concept including common indicators for biodiversity

2. Stratification of Europe and other regions involved for monitoring purposes

3. Development and testing of standard field site observations and database management

4. Intercalibration of field data with earth observation data

5. Development of a cost effective framework for European and world-wide biodiversity monitoring including suggestions for an institutional setting.

The framework developed in this project is tested outside Europe in Mediterranean and desert regions. The project develops a habitat classification system that is based on plant life-forms, which are also used in biogeography to define world biomes. During the project non-plant life-forms have been added for desert regions. This makes it possible to extend the approach to a world monitoring system by adding life forms not present in Europe. A link is also possible with the FAO land cover system LCCS as this also used plant life-forms as criteria for classification.

A major part of the work is to examine the available habitat data, both in terms of its representativeness but also in terms of its statistical reliability. Statistical tests are being carried out to measure the added value of integration in order to make recommendations for a sound and cost effective observation system. The project therefore identifies biodiversity variables to be used in indicators; it links them to in situ habitat data that can be linked to RS data enabling inter-calibration and allowing both upscaling and downscaling to be carried out.

The objectives have been elaborated into ten work packages with the following tasks:

1. The overall objective of WP1 is to agree on the conceptual framework for an integrated biodiversity observation system and oversee the development of the strategy for its achievement;

2. In WP2 an analysis of responsibilities, approaches and existing methodologies data has been carried out;

3. In WP3 the creation of a statistically robust framework for monitoring is elaborated as the basis for a system for Europe-wide statistically reliable, geographically referenced and comparable data collection of species and habitats;

4. The task in WP4 has been to develop protocols for the coordination of existing data on biodiversity indicators for input into other Work Packages;

5. In WP5 the overall objective has been to assess the improved efficiency of inter-calibration between remote sensed and in situ data;

6. In WP6 field testing has been carried out of the methodology developed and to ensure that the categories and data structures are transmissible, repeatable and appropriate for diverse institutions and regions.

7. The objective of WP7 is a data sharing system that is standardised in parameters and methods, that is easily available and accessible with the help of standardised but advanced IT tools.

8. In WP8 the results for Europe are brought together by proposing the institutional arrangements and the conditions to be met in order to establish time and cost effectiveness of the proposed surveillance and monitoring system.

9. The expansion to regions outside Europe and contribution to a World Wide Monitoring system is concentrated in WP9 by developing a prototype system for monitoring Mediterranean and desert ecosystems outside Europe.

10. Finally, the task in WP10 is to obtain feedback from stakeholders and to disseminate the results of the project.

These Work packages have produced 23 deliverables, such as a list of indicators, a recommended Institutional framework, the top-level tiers for Global Ecosystem Classification and Mapping Initiative (GEOSS Task EC-06-02), a protocol for converting data sources into common standards, a rule based system for identification of Annex I habitats, a Manual for field monitoring, reports on potential of intercalibration, on phenology related measures, a data warehouse and related technical specification of the information system for EBONE ad web portal, a report on the design of a cost-effective biodiversity monitoring system, integration of the results in Israel, South Africa and Australia in the classification system and online publication of the major reports.

Project Results:

Indicators have a wide range of uses according to geographical scale (e.g. from local to global) and user domain (e.g. scientific, site condition assessments, resource management, and policy purposes). EBONE aims to provide access to indicator data for reporting for the Convention on Biological Diversity (CBD) against the 2010 target as currently covered by the Streamlining European 2010 Biodiversity Indicators (SEBI, European Environmental Agency, 2009). The developments made by EBONE provide results that:

- Enable cost-effective reporting on the agreed SEBI indicators;
- Help develop and provide a system for data collection including the better use of stratification and habitat classification;
- Provide background information and understanding necessary to interpret indicators, understand processes of change;
- Identify a core set of measurements for biodiversity, combining species and habitat level measures, to enable consistent approaches to the assessment of change in the status and extent of habitats of European interest; and
- Help define the requirements and technological specifications for the use of in situ and EO sensors and computer technologies to enable real-time monitoring of biodiversity and ecosystem processes.

Selection of Indicators

The main aim of selecting indicators was to identify which biodiversity indicators should be selected as the basis for developing new for assessing biodiversity. These methodologies combine different types and scales of biodiversity relevant observations and the basis of the recommendations on the design and implementation of the European Biodiversity Observation Network.

The development of EBONE and the choice of these test indicators are set in the context of the emerging goal to develop a GEO Biodiversity Observation Network (GEO BON) and its implementation within an institutional framework operating at the European level. One of the main requirements from EBONE was be to provide better access to data for among others CBD reporting against the 2010 targets at national and European levels. Hence, the indicator selection process began with a brief overview of biodiversity indicators used (or proposed) in large scale (national, continental or global) programmes. It covered indicators in the GEO Biodiversity Observation Network (GEO BON), the European CBD indicators (SEBI), composite indicators and indicator taxa.

To identify appropriate indicators for this development work we undertook an expert assessment of the SEBI Streamlining European 2010 Biodiversity Indicators set of 26 indicators taking account of: the availability of data; and the potential added value of combining data from different sources (including BioHab) to produce a more cost-effective set of indicators. The conclusion of this assessment was that EBONE would focus its initial development work on three main headline indicators covering: (i) habitats of European interest in the context of a broad habitat assessment; (ii) abundance and distribution of selected species (plants); and (iii) fragmentation of natural and semi-natural areas.

The lack of data that fit the indicators is a big constraint on its development and use for large-scale (national, European and global) biodiversity assessments. Two of the key questions EBONE has addressed are:

(i) can we make better use of the existing biodiversity observation data (e.g. to produce indicators) by combining them in novel ways and making better use of remote sensing technologies; and

(ii) are there some simple observations that could be used across Europe within existing programmes and that would give added value to existing data?

The types of data we are looking to combine in this process are collected at different scales and with different methodologies and levels of sampling intensity. They include in-situ biodiversity survey and monitoring data on species or habitats i.e. from field observations or samples as well as remote sensing data, both satellite and airborne data sources. In the course of the project and in the development within GEO BON these variables have later been named Essential Biodiversity Variables (EBVs).

Long Term Ecological Research sites have been analysed on their data availability and the possibilities to include these. It appeared not possible to obtain systematic in-situ biodiversity data from Long-term Ecosystem Research Sites (LTER) in Europe. An analysis of among other the EuMon database has shown that there are other major gaps in the coverage of biodiversity data at the European level. The most significant gaps for the delivery of biodiversity indicators are in relation to systems for monitoring changes:

- the extent and quality of habitats;
- the lack of systems and models for combining in situ observations with remotely sensed data to provide reliable European statistics;
- The possibility to carry out reliable 'wall to wall' assessments of a broader range of biodiversity indicators;
- The lack of time series in European Biodiversity data except for national programmes such as the Great Britain Countryside Survey, The Northern Irish Countryside Survey, the Swedish NILS programme and in a more restricted sense the Dutch National Ecological Monitoring.

Essential Biodiversity Variables

In EBONE as well as in GEO BON it has been considered essential to reach a common understanding on the core set of information that must be monitored in a comparable way. This core set can be different for different regions and objectives, but there also will be common essential variables. In comparison to Essential Climate Variables (ECVs) we refer to these as Essential Biodiversity Variables (EBVs).that require a multidisciplinary ecosystem approach to develop them.

The 2004 Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC (IP-04) and its 2006 Satellite Supplement use the list of ECVs as the basis for their detailed specifications of requirements, which are provided variable by variable. Since then the ECVs have achieved increasing recognition. A closely-related example is that of the proposal to assign Essential

Ocean Variables as the organisational basis for processes of the Framework for Ocean Observing being developed as an outcome of the OceanObs 09 conference.

As part of a process to assess the adequacy of observation capabilities for the 2020 Aichi Targets under the UN Convention on Biological Diversity (CBD), EBONE organised an experts, workshop in Wageningen, 1-3 March 2011. The meeting was attended by more than 50 specialists. As part of the adequacy report (http://www.cbd.int/doc/meetings/sbstta/sbstta-15/information/sbstta-15-inf-08-en.pdf) produced at the meeting, a section on EBVs was included and incorporated an indicative framework for deriving measures of biodiversity change (relating to pressures, states, responses and impacts/benefits) from primary change observations, as well as a preliminary suggested set of essential variables.

The conclusion of the meeting was that it will be important to develop further a set of variables akin to the Global Climate Observing System's (GCOS) Essential Climate Variables (ECVs) as used in the UN Framework Convention on Climate Change. Following this, at the fifteenth meeting of the CBD's Subsidiary Body on Scientific, Technical and Technological Advice (7-11 November 2011) GEO BON was invited to continue its work on the identification of essential biodiversity variables to shape global biodiversity monitoring. On request of the SBSTTA of the Convention of Biological Diversity the EBVs are being developed first in a workshop at ESA in March 2012 organised by GEO BON.

The envisaged EBVs for global monitoring on biological resources will include marine, freshwater and terrestrial ecosystems, habitats and species, functional traits and genetic diversity. It will include existing data, agency based data and citizen science, and in situ observations combined with RS data. EBVs can be from all kind of sources and they will require integration of in situ observations (e.g. species, habitats and ecosystem trends) with RS data on change (e.g. land cover, sea surface chlorophyll). The EBVs will be related to socio-economic, climate and pollution data as drivers of change. The challenge is to identify variables and data for each of the main levels of biodiversity, genes, species and ecosystems, and link them to the Drivers-Pressures-State-Impact-Response (DPSIR) framework, in terrestrial, freshwater and marine domains. A thorough expert discussion is required to identify the candidate variables for defining a first list of EBVs.

The European Environmental Stratification

Environmental stratification into homogeneous biophysical regions helps in the comparison between sites across large heterogeneous areas (Bunce et al. 1996; Jongman et al. 2006). A stratification system can provide a flexible framework suitable for a wide range of applications, including the coordination and analysis of biodiversity observation efforts and environmental assessments.

For biodiversity monitoring ecosystem maps and classical biogeographic region maps cannot be used for stratification with the purpose of monitoring as they are interpreted maps and too generalised to provide a proper basis. Biogeographic regions can form a framework for reporting and further scientific in-depth studies, but results should always be linked to the real environmental conditions. The European Environmental Stratification (EnS, Figure 1) can form an appropriate stratification for monitoring (Jongman et al 2006). Although Atlantic mountains are situated in the Atlantic Biogeographic Zone, they have Alpine characteristics and represent environmental conditions of a mountain ecosystem (Figure 2).

Figure 1. The European Environmental Stratification (Metzger et al 2005).

Figure 2. Comparison between the biogeographic zone in northern Spain and the EnS according to Metzger et al (2005). The biogeographic zone is rather uniform, as is good as a basis for country reporting. The EnS shows environmentally different strata, which makes it more appropriate for selecting biodiversity monitoring samples.

Statistical studies within the context of the BioHab project have shown that if use is made of a European stratification 15 squares per stratum or substratum are sufficient to obtain an overall picture of the relative extent of European General Habitat Categories (GHC). The estimate of sample size per stratum and the total sample for European with associated standard errors can be calculated using standard statistical procedures. In a case study for Portugal it has been shown, that even a small sample of relatively homogeneous environmental (sub)classes can provide sufficient estimates of land cover (Figure 3). Increasing the number of sample units will not change the estimate, but mainly reduce the Coefficient of Variation i.e. the proportion of error.

Figure 3. Comparison of the Portuguese land cover data base (COS) and estimates of 5, 10 and 15 samples.

The stratification is used to calculate the consequences of a sampling design. We have proposed a serially alternating space-time design with periodicity of 5 years (2000 per year). The size of the squares is usually 1 km2, however in complex landscapes or small substrata the choice may be different. In Northern Ireland, Northern Portugal and Israel ¼ km2 squares have been chosen based on the local situation.

In this proposal in the first five years different sets of km-squares are observed, in sixth year km-squares of first year are revisited and so on. The approach is stratified random sampling within the EnS stratification, A geographical sub-stratification of EnS strata takes care of spatial coverage (avoids spatial clustering of km-squares within EnS strata) and realises increased precision (Figure 4)

This serially alternating design with a periodicity of five years conforms to the National Inventory of Landscapes in Sweden (NILS, Stahl et al., 2011). It is important that the squares of a given year are selected from the entire study area, not from a part of it (for instance from a subset of the strata). This enables unbiased estimation every year of the statistical parameters (area of habitat types et cetera) of the study area in its entirety. The rate of change in habitat properties generally will be rather slow, and therefore we expect revisiting sampling squares every year to be inefficient.

For selecting the samples we must decide on the total number of squares and on their distribution among the environmental strata. The total number of squares in the EBONE sample was set at 10 000 (2000 per year). This number is not yet based on a thorough statistical analysis of the minimum number of squares given a requirement on the quality of the monitoring result.

Figure 4. Example of subdivision of stratum ALN1. The numbers indicate the year of the five year cycle that the square is being sampled. This allows the best distribution of independent sampling squares.

The Global Environmental Stratification

For developing well distributed global observations it is important to make globally stratified observation systems that can be interpolated if needed. To develop a Global Environmental Stratification we have developed a consistent numerical stratification of the global land surface resulting in relatively homogeneous bioclimate strata that provide a global spatial framework for the integration and analysis of ecological and environmental data. This is done for the global land surface excluding Antarctica.

The methods used are comparable with those used for the European stratification. Statistical screening produced a subset of relevant bioclimate variables, which were then compacted into fewer uncorrelated dimensions using Principal Components Analysis (PCA). A clustering routine was then used to classify the principal components into relatively homogenous environmental strata. The strata were aggregated into global environmental zones based on the attribute distances between strata to provide structure and support and a consistent nomenclature.

The Global Environmental Stratification (GEnS) consists of 125 strata (Figure 5), These have been aggregated into eighteen global environmental zones. The stratification has a 30 arcsec resolution (equivalent to 0.86 km2 at the equator). This Global Environmental Stratification has been constructed using tried and tested statistical procedures. It forms a rigorous framework for the aggregation of local observations, identifying gaps in current monitoring effort, targeting new monitoring and research, and supporting global environmental assessment, including the recently launched Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) and the tasks of the Group on Earth Observation Biodiversity Observation Network (GEO BON). It has already been used in among setting up a monitoring project in the Himalaya linking India, Nepal and China (Metzger et al 2012).

The primary reason for developing the GEnS was to provide a unifying framework for GEO BON activities as indicated in the implementation plan (GEOBON, 2010). It should facilitate the integration and analysis of disparate sources of global biodiversity data, and help to compare trends in similar environments as has been asked for by the CoP of the CBD in Nagoya. Furthermore, it can be used to target future monitoring and research to achieve a more balanced set of biodiversity observations. Other applications, discussed by Jongman et al. (2006) and Hazeu et al. (2010), include stratifying earth observations and scenario modelling (Metzger et al., 2008). The utility is not limited to biodiversity, but wider global environmental and agricultural research would also benefit from the dataset, for both global sub-global studies, especially where there is a need for a consistent stratification across political boundaries.

Figure 5. The Global Environmental Stratification, divided in 18 zones and 125 strata.

Mapping and Reporting using General Habitat Categories (GHC)

Habitat and ecosystem change monitoring aims to detect annual as well as long term changes in ecosystems due to natural succession as well as human influence. As noted in the GEO BON Concept Document, GEO BON will provide global information on terrestrial, freshwater, and marine ecosystems, focusing on their distribution, extent, and condition, and how these parameters are changing over time (GEO BON 2008). The EU Habitats Directive requires information on the trends in species populations and habitats. When monitoring habitats in situ, the difficulty has always been to reconcile the field measurements with recognisable habitats categories that can be consistently applied and used for European and national estimates, and harmonised for global purposes.

Habitats within each biome share a suite of biological, climatic, and socio-economic factors, and for each of these a number of variables should be measured in order to monitor their changes. During the

GEO BON Implementation Plan Meeting of 22-25 February 2010, the working groups on Terrestrial Species, Terrestrial Ecosystems and Freshwater concluded that in situ data for parameterizing and testing spatial models of ecosystems as a vital need. Such data are primary recorded from field observations, they are essential deliverables and important for future interpolations of biodiversity observations (GEO BON 2010). The quality of modelling results is directly linked to the quality and quantity of in situ data inputs as well as the distribution of the sampling sites across environmental and geographic space.

The habitat monitoring system developed in the FP5 project BioHab enables consistent recording and monitoring of habitats across Europe, and potentially, globally. In EBONE this has been further elaborated The habitat monitoring system has at present 154 General Habitat Categories (GHCs) derived from 16 easily identifiable Life-Forms and 18 Non Life Forms. The system provides an easily repeatable system for use in the field that can be cross-related to other habitat classification schemes such as Habitat Directive Annex I and EUNIS. The GHCs provide the lowest common denominator linking to other sources of data required for assessing biodiversity e.g. phytosociology, birds and butterflies, that are regionally different. They also can be discriminated from the air or space using remote sensing methods because of the system is based on (non-)life forms and on habitat structure The system provides a missing link between detailed site-based species, population and community level measures and extensive assessments of habitats from remote sensing.

The GHC mapping procedure is based on the recording of General Habitat Categories, which are defined by plant life forms. These life forms reflect the structure of vegetation and enable the main series of European habitats to be defined consistently. Thus at one extreme are the evergreen forests of southern Spain and at the other the open dwarf heaths of the high mountains and arctic environment. In the EBONE project strict rules have been developed for recording habitats consistently throughout Europe and the procedure has been validated in the field for all Environmental Zones in Europe. Life forms can be considered as being a function of environmental conditions. For instance, hemicryptophytes (perennial herbs) decrease from north to south in Europe and therophytes (annual herbs) increase (Figure 6).

Figure 6. Presence of hemicryptophytes and therophytes in Italy from north to south (Pignatti 1994).

As in principle it should be possible to map the entire land surface, General Habitat Categories exist for urban, crops, sparsely vegetated land and vegetated land. For each polygon, information regarding global, site and management qualifiers is added in a standardised way. Detailed life form composition and dominant species are also recorded as well as basic information on biodiversity. Explicit definitions are provided for life forms and qualifiers and strict rules for mapping, so that the problem of subjective interpretation is kept to a minimum. All procedures and descriptions can be found in the manual at http://www.ebone.wur.nl and in Alterra Report 2154 (http://www.alterra.wur.nl).

This classification system includes detailed information on environment, site, management and species composition that can be used as the primary structure for recording ecosystems. It also provides links to national and other higher level, continental ecosystem classifications. Many qualifiers have already been added to cover situations outside Europe but they will need testing in a variety of situations to ensure they are robust.

The Land Cover Classification System (LCCS) approach of the FAO for classification of land cover data is based on Plant Life Forms (Raunkiaer 1934) as a global unifying concept (Di Gregorio and Jansen 2000). The EBONE habitat classification and the FAO Land Cover Classification System can be linked and can form a global habitat and ecosystem classification system, that will satisfy the needs of global biodiversity monitoring and link in situ directly with Remote Sensing. This is been further elaborated in a follow-up GMES project BIO SOS (http://www.biosos.wur.nl)

To test the approach field data was recorded in 94 squares using the EBONE habitat mapping methodology. The objectives of the analyses of the data recorded are not to produce representative estimates but to test in-situ the EBONE habitat recording protocol from the acquisition of data in field to the processing of the data and production of a set of indicators.

The EBONE data is composed of two main components. Firstly, a GIS shapes layers that store the location and shape of areal, linear and point elements at the landscape level. Secondly, a database in which are recorded the nature and qualifiers for every elements created in the GIS layers.

Three main type of information are recorded per element encountered in the field (see the EBONE field recording manual for in depth description of the different typologies:

- The nature of the elements using a comprehensive and flexible typology based on structural elements and plant life forms;
- Plant life form and species recordings using standard protocol and survey methodology;
- Environmental and Management qualifiers.

Table 1: number of sample squares used for data analysis per country and per environmental strata.

A selection of indicators is presented in this deliverable, but the EBONE protocol allows to record a large number of parameters form habitat, life forms, environment, management, biodiversity and a much large range of indicators presented in this deliverable can be derived in a flexible and controlled way.

The field test of the EBONE protocol has been done in 12 European countries within the WP6 and 3 more countries in WP9 (Israel, Australia and South-Africa). Table 1 summarises the final dataset used for the data analysis. It should be stated that the sample set used is too small to derive statistically significant figures for the indicators that could be used for reporting and that at this stage the spatial sampling is fully complying with a stratified random protocol.

Figure 7: Spatial location of the 94 landscape squares surveyed during the EBONE

Since the first version of the Manual was produced major advances have taken place in the application of field computers for the recording of habitat data. Various options are now available and, except in GB, the spatial data is not yet stored in a fully integrated way within a GIS environment. It is important to note that all systems involve previous interpretation of different types of aerial photographs to produce parcel outlines which are then validated in the field.

The Flemish Institute for Nature and Forest Research (INBO) has developed a system for recording GHCs and associated data on qualifiers and species in the field which is transferrable to other machines. The system developed by INBO has been adopted for EBONE for input into a PDA. The PDA also includes the key to Annex I Habitats developed by Alterra. A Manual and software are available for application of the system.

Within the EBONE consortium IRSTEA/IRSTEA has developed a system for tablet PC within an MS Access environment that was used for the current report (Figure 8). The Access database is available and can be downloaded from the project website. Each of the three main type of information can be used on its own or in combination in order to derive indicators for habitat, species, environment and management status. The spatial information recorded in the GIS layers can also be used to derive landscape scale indicators or/and to compute quantitative indicators by crossing spatial and descriptive data.

Figure 8. Screenshot of the Access database on the tablet computer for the square Jois in Austria. The picture is geotagged. The data are included in the Access database and collected later in the GEO database.

The data and indicators derived from the EBONE data can contribute to the following analyses:

- To link habitat information to species data;
- To analyse the habitat composition on the aggregation level of member states and environmental zones;
- To use habitat information on species diversity to explore alpha-, beta-, and gamma-diversity;
- To explore the possible contribution of habitat information to the SEBI indicators;
- Perform multivariate analysis as a sensitivity analysis of the methodology and to illustrate the potential use of the EBONE methodology to stakeholders.

To do the proposed analyses, certain basic indicators for habitat and species diversity need to be computed. In this document these indicators are described at a general level. After having decided that these indicators are indeed the required indicators, we will develop calculation protocols for these indicators. The Indicator groups are:

Patch: Habitat Patch Density: The number patches per (km2), Habitat Patch Area and Perimeter: Mean area of Patches per square

Habitat: Habitat Coverage: The surface area (unit m2 or ha) of each GHC (or a coarser habitat level), Habitat Richness Density: The number of GHC (or a coarser habitat level) types per (ha or km2), Habitat diversity: computed from proportional area of each GHC (or a coarser habitat level) types per km2 (using diversity metrics such as e.g. H Shannon, H Simpson or Evenness)

For the analysis, habitat categories can be used as coarse as the first level in the GHC and as detailed as combinations of qualifiers and full level GHC's. Analysis should start at the lowest level and continue towards more details. To clarify the computations of the indicators, the queries are represented using a flow chart (Figure 9). The computation base remains the same; it is merely based on database queries at the element level, only the fusion phase change.

Figure 9 : Query flow from database and GIS attribute table to habitat coverage indicators.

Habitat Richness Density (HRD) has been defined as the total number of different habitats within a sampled area. The range of HRD is primarily related primarily to habitat typology; the coarser the habitat typology is (few types) the smaller is the range of Habitat Richness Density. HRD is an indicator of biodiversity, the total biodiversity at landscape level (gamma) is positively related to the number and range of habitat types (Weibull et al. 2003). The relation between HRD and biodiversity is highly dependent on the habitat types and species biodiversity could be correlated with HRD and the area of important habitat types (Dauber et al. 2003). In order to explore the dependency of HRD on values to the typology, we used three levels of the GCH typology.

- Level 1: GHC Super-categories (Max. = 5)
- Level 2: GHC without leaf type (more structural, comparable to CLC; Max. = 40)
- Level 3: GHC with leaf type (Max. = 140)

The level 1 is related the diversity of the major categories of habitats and a high value will indicate a very diverse landscape in type of habitat and management types. The level 2 and 3 are related to structural variability of habitat types and a can reach high values even in landscape that were not very Habitat rich at level 1. A natural landscape can be composed of only two GHC super-categories (Herbaceous and Tree/Shrubs) and have a high Habitat Richness at GHC level 2 and 3 indicating the occurrence of many different subtypes of habitats. As expected the value of the HRD increases as the number of types increases per level (Figure). A higher HRD number indicates that the km2 sampled in that country has a higher diversity in their patch types when looking with a more detailed typology. GHC L3 is related to the photosynthetic type of leaves of TRS and countries with a higher variability in the vegetation leaf types increase the most in their HRD from Level 2 to Level3.

Figure 10: Average Habitat Richness Density per country and Environmental Zone for 3 levels of precision of habitat typology.

The timeframe of the management activities makes it possible to get an indication of the intensity of land use in a sample set (Figure 11). This can be a very important explanatory factor in biodiversity differences between samples in the same regions. Also it can help to understand differences between countries. An illustrative indicator for what is going on in a region could be the ratio of land management time between active and recent versus Neglected, Abandoned and Ancient. If this percentage reduces over time, it is clear that either abandonment is taking place with positive effect on the species associated with undisturbed environments.

Figure 11: Time of activity profile for management per countries.

Finally, based on the field data the occurrence of Annex I Habitats can be assessed. This allows to return figures about the areas covered by Annex I habitats but also to make cross queries to analyse the occurrence of these habitats regarding management indicators (table 2) or environmental strata. The results from the EBONE dataset show that some Annex I habitats seem to be restricted to a given type of management. As an example are Annex I habitat 5330 being entirely semi-natural or the habitat 6230 that is entirely within agricultural management. But other habitats seem to occur over a large range of management types, i.e. Annex I habitat 4030 (European dry heath) is encountered in Agricultural, Semi-natural, Forestry and no management situations). This can be further interpreted in threats and trends.

Table 2: Percentage of Annex I habitats by management time line

Linking RS with in situ biodiversity information

Post-stratification

RS information can support in situ data. When only statistics and not wall-to-wall maps describing the spatial pattern of different habitats or categories are needed, the combined use of RS data and data from sample-based inventories can provide accurate area estimates for various categories. Improved area estimates of habitats or classes can, for example, be obtained by combining RS data and in-situ data using post-stratification. The main requirement is that there is a reasonably correlation between the classes of the RS map and the and the in-situ determined categories to be finally estimated, but the RS-derived classes do not need to be the same as the in-situ derived classes. CORINE land cover data was used to post-stratify in-situ data from the LUCAS sample based land inventory to improve the accuracy of area estimates for various coastal land cover classes.

EBONE tested this approach for one of the nine environmental strata of Sweden combining the comprehensive NILS inventory data (NILS; http://nils.slu.se/) with the EO derived Swedish GSD land cover map (Newberg, 2005). The results obtained in this study also show an increase in precision when using classified satellite images for post-stratification. This confirms that post-stratification is an easy and straight forward method that can be used to derive improved area statistics for habitats. One important advantage of using products like the GSD Land Cover map or the CLC2000 map for post-stratification is that they already exist. The increase in precision obtained using post-stratification also means that estimates of the area covered by different habitat classes can be presented for smaller areas than possible from estimates based on a sparse sample of in-situ data alone, without any reduction in precision.

Extrapolation

In the study in Almeria (Spain) Estonia we showed that Landsat-7 ETM+ can be used to extend detailed information from limited field monitoring sites of the European Biodiversity Observation Network. An atmospherically corrected image from 28. June, 2010 was classified using iterative self-organizing clustering and maximum likelihood method. A Landsat-7 ETM+ image acquired in SLC-off mode was used for a test area in Estonia to extend detailed information from limited field monitoring sites.

- Unsupervised image classification was useful to examine the spectral variation in the image, within field mapped GHC areas and to locate those areas for which the supervised classifier did not have a like training area in the monitoring square.
- Supervised maximum likelihood can be used to extrapolate knowledge from EBONE field monitoring squares to a wider area by using each delineated GHC area as an individual class training site. However, in medium spatial resolution multi spectral images the pixel count requirement for signature development excludes small GHC areas which can be important for some aspects of biodiversity. Single central monitoring square can be non-representative for surrounding squares.
- By using training areas from several monitoring squares there is more chance for a pixel to be classified in a wrong class because the GHC areas are internally spectrally nonhomogeneous. On the other hand, objects from different classes (e.g. CHE,LHE and CRO) can have similar spectral signatures.
- Extrapolation from the 1 km square to the surrounding area seems to be feasible using HYMAP satellite imagery (and to a lesser extent for Landsat TM imagery). Only a few of the

spectral classes from the HYMAP image did not occur in the central sample square. These spectral classes need targeted field visits.

- Supervised classifications of satellite imagery are only possible when targeted training samples have been collected in the field. This is especially valid in semi-arid regions where the contrast is also very high within and between mapping units.

- Minimum likelihood threshold in maximum likelihood classifier was useful to some extent to distinguish pixels that caused classification error. Minimum likelihood threshold=0.05 resulted in 5-15% of unclassified pixels in use-single-square test and 20% of unclassified pixels in use-all-training areas test.

Phenology studies, RS sensor comparison

Several teams in the EBONE project have tested the use of phenology sensors, JRC, ILE-SAS and INPA. They had different approaches but their conclusions can be well compared.

The JRC Phenolo model (version 2009) allowed the extraction of a large set of date and productivity phenology indicators from SPOT and MODIS NDVI time series. Model coded in IDL provided fast calculations within a stable environment. The degree of information redundancy (based on calculations of correlation matrix) present among the 31 Phenolo phenometrics suggests it is possibly to focus on smaller sets of indicators instead than a large set of metrics without reducing the effectiveness of a classification.

JRC and ILE SAS have demonstrated that the Random Forests (RF) classification technique is an attractive method for classifying remotely sensed data because (Gislason et al., 2004):

1) it is very fast in training large datasets,

2) it provides an error measure based on the set of training pixels (OOB), and more importantly

3) the RF algorithm gives an indication of variables importance in the classification.

In the tests performed, the Mean Decrease Accuracy (MDA) calculation generally indicated date phenometrics as more important for classification than productivity phenometrics. The most recurrent phenology indicators (top of MDA graphs) were located around the Peak of Season point (MXV, MXD) and the curve absolute minima (MBV, MEV). Nevertheless, further analyses are needed to infer more general rules on single phenometrics importance, as defined by Phenolo, for habitat classification. In our tests, in presence of correlated phenometrics and well differentiated training pixels among classes, the use of a small selected set of phenology indicators produced higher classification accuracy. This trend can be different when these conditions are not respected, such as using noisy training datasets.

Apart from spatially and spectrally homogeneous classes (FPH/CON in Austria), the overall classification accuracy achieved based on Random Forests and MODIS-based phenology indicators is generally not satisfactory. The following factors were considered to negatively influence the intercalibration exercise:

1) The GHC scheme makes use of general categories that allow degrees of heterogeneity in the classification of the same habitat category. For the GHC forest category (FPH) the proportion of treed

vegetation covers ranges in the wide interval from 30% to full coverage. This heterogeneity is reflected in remarkable variance associated to the NDVI trends of the training pixels, and consequently in the RF classification. In Mediterranean or semi-arid environments this is possibly more evident, due to the characteristics of the different bare or scarcely vegetated soils.

2) The number of GHC field plots data currently available did not allow retrieving highly populated sets of pure pixels for the classifier training. This would limit the possibility to take into account the large variability of GHC forest vegetation signal over different environmental zones. Moreover, no pure pixels were obtainable for the FPH/EVR class, thus introducing an additional noise component.

3) The accuracy assessment was performed using information from the JRC Forest Cover Map 2006. This continental dataset, built uniquely on spectral information, has no rigid correspondence with the GHC forest classes. Hence, increased mismatches could have been measured when comparing the datasets.

On the basis of the above results our concluding remarks are as follows:

- The spatial scale of current EO-based phenology data (250 m) is at the edge of an adequate resolution for effective habitat classification with respect to the GHC categories. MODIS 250 m grid overlapped on high resolution GHC field plots provide polygons with a variety of mixed classes, which are difficult to classify and unmix.

- For the intercalibration of GHCs with EO-based phenology indicators, the production and use of a large dataset of GHC training pixels (pure pixels) is recommended to take into account the high spectral variability present within single GHC classes. This can be achieved by the sampling of several field plots in different Environmental Zones with a variety of local conditions.

- An adequate classification accuracy assessment should be based on a reference dataset which is not processed uniquely using spectral information, but that is built taking into account as much as possible the elements of heterogeneity typical of the General Habitat Categories. This can be possibly addressed using regional or national habitat map and datasets.

The conclusion from this work was that the elements characteristics of the life forms types considered in the General Habitat Category scheme (e.g. height of stand) are very valuable information to be taken into account in intercalibration using EO-derived information. For this reason and for the purpose of GHCs classification a strategy, which integrates EO-based phenology indicators with LiDAR or high resolution radar, can be potentially more effective than a purely phenology-based approach.

The Israel team used three passive sensors in the VIS-NIR-SWIR spectral regions, offering varying spatial, spectral and temporal resolutions: MODIS (250 m, every 16 days, 2000-2010), Landsat (30m, four seasons, early 2000s) and QuickBird (2.4m, spring and summer 2010, specially tasked for this study). Phenology was the key to differentiate between vegetation and land cover types. Several mapping methods were applied, including supervised and unsupervised classification, spectral unmixing, time series analysis of significant trends and of abrupt changes. The results were as follows:

- Landsat. Following a preliminary analysis it was found the topographic correction of shading effects was important for improving classification accuracy. Overall classification accuracies of the Landsat images were at the order of 90% (when using validation sites identified by us), but were lower in the Mediterranean sites when using the EBONE GHC field mapping validation sites (between 30% to 60%, after merging some of the EBONE classes). Among classes, trees (including maquis) were mapped well (accuracies between 60% to 90%), whereas the success in mapping the shrubs and herbaceous classes was lower within the supervised classification. Mediterranean areas were reasonably classified, with the general distribution of perennial and herbaceous vegetation, agricultural areas and even the major urban areas showing quite well. However, desert areas were not differentiated, and were mostly classified as bare soil.

- QuickBird. QuickBird imagery was used to spectrally unmix into the per cent cover of perennial green vegetation, seasonal green vegetation and bare soil (as in the Landsat imagery). The improved spatial resolution of QuickBird allowed the mapping of sparse vegetation cover, undetected at the spatial resolution of Landsat. Supervised classification of the QuickBird imagery was done using pixel-based approaches as well as using object-based image segmentation. The latter approach allows for an objective segmentation of the image into homogeneous areas. The spectra of coniferous trees of cypress (and to a lesser degree of pines) was shown to be different than that of maquis, enabling the separation of these vegetation classes (overall accuracy of 75% in Ramat haNadiv site).

- MODIS. The NDVI time series of MODIS were denoised using Fourier transformation to remove erroneous data related to atmospheric attenuation. Statistically significant trends in vegetation cover were identified using the denoised NDVI time series, and were related to decrease in rainfall, recovery of vegetation from wildfires, and the development of built-up areas, to name just a few factors. In addition, the time and size of large fires can be mapped using raw MODIS time series (prior to noise removal).

A supervised classification based on a neural network classifier and a decision tree, was able to classify not only general land cover types, but also demonstrated that planted coniferous forests can be separated from maquis, based on their time series properties, mainly summer (minimum) NDVI values and the coefficient of variation (CV) values of NDVI, which are different (within rainfall zones) between maquis and coniferous trees (an overall accuracy of 77%).

Overall remote sensing methods using operational passive sensors have been shown to enable the monitoring of gradual and abrupt changes in land cover and also enable mapping of broad types of Israel's land cover. The full breadth of EBONE classes was found to be too detailed to be replicated using passive remote sensing. Using phenological data the work in Israel has shown that perennial vegetation, seasonal vegetation and bare soil can be mapped at the sub-pixel level. Using detailed time series, monitoring of changes can be achieved, and the spatial distribution of seasonal vegetation can be mapped, being of special interest in the transition zones and the desert, where rainfall is highly variable in space and in time. One of the challenges in mapping Mediterranean vegetation is that of separating between maquis and coniferous planted trees. Ysing either high spatial resolution or detailed time series, maquis and coniferous trees can indeed be separated, at accuracies > 70%. Also the Israel team concludes that the combination with LiDAR could be useful.

The use of LiDAR

LiDAR provides accurate height measurements on shrubs and trees. Even in early spring when the objects of interest still did not have any leaves. Early spring is the standard time for LiDAR measurements over the entire area of the Netherlands (primary interest is the update of the Dutch elevation model). Regression analysis between field measurements and LiDAR measurements of the height of various plant life forms showed an adjusted R square of 0.95. Unfortunately, not the whole range of plant life forms could be measured with LiDAR. Since the latest generation of LiDAR measurements have an accuracy of approximately 2 to 3 centimetres, it is assumed that cryptogams and dwarf chamaephytes (below 5 cm) are difficult to measure with LiDAR. In general, it has been demonstrated in this study that good characterization of 3d-vegetation objects is possible with LiDAR. But surprisingly, there were also problems with the identification of some specific vegetation types, such as fields with Juncus effusus (caespitose hemicriptophytes). This vegetation type does not reflect any LiDAR measurements and is therefore invisible for LiDAR. Occasional data gaps occurred through shadow effects, but the use of different scan angles solves this problem. Combination of LiDAR with false-colour aerial photographs provides a power tool with e.g. FUSION software and decision tree classifiers for the identification of plant life forms. Additional combination with topographic maps was needed to mask out urban environments for which EBONE does not distinguish plant life forms.

A major challenge was to identify the proper habitat patches based on segmentation of the classification result, in order to translate the composition of the plant life forms within the patch to a General Habitat Category (GHC). Comparison with a full field survey of the general habitat categories was essential. Segmentation and classification results are quite satisfactory based on the combined use of LiDAR, topographic maps and aerial photographs using segmentation as well as decision tree classifiers (using spatial modeller in ArcGis). It has been proofed, that in some cases estimates based on a semi-automatic classification are better than the estimates made in the field. Moreover, semi-automatic classification could save costs in the end. Major concern remains, that not all plant life forms can be identified on basis of remotely sensed information, in the first place due to the fact that acquisitions were made in early spring when most vegetation is still not present. Combination of LiDAR (height) measurements in combination with more species specific hyperspectral measurements is the way forward to identify General Habitat Categories from space.

Data management

The EBONE information management framework has to deal with habitat and species monitoring data, as well as data from earth observation dealing with habitat and species occurrence. The data types for the EBONE network that has to be dealt with are:

1. Field data

- Data mapped according to the EBONE mapping procedure (GHC/species) on new sites. These data are fully compliant with the EBONE data structure and raw data should be available in most of the cases. This data originate either from test mapping activities within the EBONE project or in a later stage from implementations from the EBONE habitat and species monitoring protocol on the national or regional level.

- Data from existing monitoring schemes, which are harmonised and transformed according to the EBONE transformation rules for GHC/species. These data are based on different data models, which can have a certain level of compliancy to the EBONE data structure.

Furthermore often raw data and their metadata cannot be directly accessed but only aggregated values for different parameters for a defined analysis unit (e.g. landscape squares) are available.

2. Earth observation data

- Land cover data or other remote sensing products (e.g. phenology, fragmentation)

- Hyperspectral and LiDAR data. The data management in EBONE has to be able to deal with different data characteristics and take into account aspects of data policy and data rights. The data management system also has to address data on different levels, which can be distinguished as

- Raw field data on the level of the landscape square. These are the mapped data (e.g. GHC or other habitat classification according to the mapping protocol) together with their exact location and shape (spatial information).

- Aggregated data on the level of the landscape square. These are transformed (according to the GHC) and aggregated values, e.g. as sum of area (or proportion) of habitat categories or species per landscape which are the basis for further calculation. The exact spatial location of the landscape element within the landscape square is not provided. In some cases not even the exact location of the landscape square is provided but only the assignment to an Environmental strata or zone.

- Aggregated data on the level of the reporting unit (e.g. Environmental Strata and Zones). The Environmental stratification forms the basis for the calculation of the indicator values. Therefore this data level is based on aggregated figures of selected indicators based on the entry values of data level II for the Environmental Strata or Zone. Theoretically every other reporting unit is possible if the data meet the statistical requirements for the calculation of the indicator values for this reporting unit.

Cost-effectiveness sampling

In the EBONE project we have explored the implications for a cost-effective monitoring design. The problem we want to solve is how to achieve a good balance between output quality of the design and available monetary budget or alternatively, the constraint could be formulated in terms of time. The effectiveness can often be related to statistical concepts, such as the margin of error or the sampling variance. Which measure for effectiveness will be most useful; will depend on the question at hand. For estimation of a mean or a total, higher effectiveness is related to a narrower confidence interval, as we have shown. For trend detection, the effectiveness will depend on the power to detect a trend, and thus this will depend on the magnitude of the trend that needs to be detected.

For a given sample size, we can thus assess effectiveness. The pilot data gathered during the EBONE project also allow us to get insights into time requirements for field work (see D8.1 for more details). Confronting the time requirements with the effectiveness yields a first rough approximation of cost/time-effectiveness gives a summary of effectiveness for stock and change detection and time requirements for the EBONE design.

At the European level, precise stock estimates can be obtained for habitat that is present in 5% or more of the sampling units. Change estimates (± 5% after 5 years) will also have sufficient power (> 80%) provided that the habitat occurs in at least 5% of the sampling units and that autocorrelation is very high (which is often the case). However, rare habitat types, among which many Annex I habitat types will not have precise stock estimates nor sufficient power after two cycles for change detection.

At the level of an average biogeographic zone, the reduced sample size evidently lowers power and precision. Still, for common and widespread habitat types precise stock estimates can be expected (cf. the UK CS). Change detection depends strongly on the autocorrelation that can be expected for the habitat type. Insufficient power is certain for dynamic habitats, whereas stable habitat types may have fairly high power to detect the change.

Table 3: Evaluation of effectiveness of the EBONE sampling design and a tentative indication of the amount of time required to gather and input the data.

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Potential Impact:

The clients

The United Nations system and related governance processes have demonstrated a steadily increasing interest in drawing on scientific information and advice to fulfil their responsibilities to advance human health, welfare, and development, while better managing and conserving the environment and natural resources. This has often been done via Multilateral Environmental Agreements through, for example, the Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) of the Convention on Biological Diversity (CBD), the Animal and Plant Committees of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), and the Scientific and Technical Review Panel (STRP) of the Ramsar Convention on Wetlands. One of the recommendations of the CBD at COP9 in Bonn, May 2008 was that the initiation of a Biodiversity Observation Network was noted and that Parties were invited, governments and relevant organizations, scientists and other relevant stakeholders to support this endeavour. The work done through EBONE is considered to contribute to this and therefore we actively contribute to fulfil the needs of the global conventions.

We have worked to strengthening our ability to monitor biodiversity at all levels and to strengthen the capacity to mobilize and use biodiversity data, information and forecasts through participation in the Group on Earth Observations Biodiversity Observation Network (GEO-BON). EBONE among others facilitated and contributed to the GEO BON report for the SBSTTA on observation capabilities of the Aichi targets (http://www.earthobservations.org/geobon.shtml).

In 2010 an agreement has been reached to set up an international Panel on Biodiversity and Ecosystem Services (IPBES). This might become one of the most important drivers for global harmonisation in biodiversity observation as it requires harmonised data and harmonised knowledge. IPBES is being established as an Independent Intergovernmental body administered by one or more existing UN org (UNEP/UNESCO/FAO/UNDP). IPBES will respond primarily to requests from governments, including conventions (CBD, etc.); others (UN, private sectors, NGOs) can submit requests to the Plenary.

Also UN scientific advisory groups such as the Intergovernmental Panel on Climate Change (IPCC), the leading body for the assessment of climate change, makes use of monitoring information through the models that it applies. Ecosystem and biodiversity information is part of its data needs. Within the European Union coordinating the implementation of and reporting on biodiversity policy that is the formal responsibility of the national and regional governments. Beside the national and regional agencies it can also be that data are collected by universities (Northern Ireland, Sweden) and in many cases NGOs collect data on special species groups.

EBONE recognises all these organisations as potential clients for using the systems developed, both the in situ and RS methods. Reporting at the European level requires proper estimates of biodiversity at national and EU/EnZ level is required and feasible for a European biodiversity information system. It is possible to design a harmonised European monitoring system using European environmental references, but this requires collaboration between countries and regions will be important for designing cost effective sampling. It also implies that the issue of data sharing and confidentiality has to be solved between agencies and between NGOs. EBONE has therefore communicated with all of them and delivered services to them.

At the European level the clients are considered to be the European Environmental Agency and tits topic Centre on Biodiversity. With which an intensive collaboration has been established during the project. Also with DG Environment exchanges have taken place. Very important are the national and regional Nature Conservation Agencies in the member states and in the countries associated with the EEA for exchange and collaboration. Partly this has and will continue through direct contacts and partly this is done through the ENCA (European Nature Conservation Agencies) network. These are the organisations responsible for direct implementation of operational monitoring. Beside these official agencies strong contacts have been held and will be continued with the data collecting NGOs throughout Europe, whenever possible.

Project website

More information can be found at: http://www.ebone.wur.nl . After the project the website has been reshaped with emphasis on products, deliverables and publications. Furthermore, project logo, diagrams or photographs illustrating and promoting the work of the EBONE can be used with reference to the project and its funding through FP7.

Use and dissemination of foreground

EBONE contributes to European policy integration as well as worldwide integration with a specific emphasis on biodiversity monitoring and nature conservation. To achieve this aim EBONE engages with a wide audience, including the scientific community, European and national/regional policy-makers and conservation managers/practitioners. Through its large pool of partners, stakeholders and associates, EBONE has a substantial and solid foundation for disseminating its results and products and for supporting European conservation policies and GEO-BON.

Section A: Dissemination and Communication

The scientific community will be particularly targeted with:

- Framework and guidelines for monitoring biodiversity improving mutual data exchange and collaboration;
- Methods developed in EBONE through downloadable reports from the website
- scientific publications in high level journals and availability for download if possible

The EU, national and regional agencies in charge of reporting on implementation of biodiversity conservation policies and the practice community will be particularly targeted with the:

- User friendly methods for monitoring and validated methods for analysis of both EO and in situ data;
- Making available of the databases and manuals for practical work
- Web based instructions for habitat monitoring (http://www.ebone.wur.nl).

The methods for habitat, ecosystem and landscape biodiversity monitoring are aiming at the regional, national and EU agencies in the biodiversity sector and in other sectors involved in biodiversity impacting. The EBONE methodology is now being testing in Switzerland and applied in Israel. The project seeks to transfer further knowledge at the science-policy interface for allowing informed decisions. Synergies with ongoing activities such as GEOSS have been promoted and will be developed further. This is done through:

a) Website is accessible for all audience, but with a particular relevance to the research and policy communities at all levels. Its content is now focusing on: deliverables, products and publications. Project posters, brochures and leaflets are still downloadable and disseminated through the web and through stakeholders. All are free downloadable. The website will remain the main presentation forum of EBONE and will enable anyone to find out about the project results and to request more information. It will remain to be managed by Alterra for the coming year. It will be discussed with GEO BON if transfer of products or direct links are possible.

b) The final symposium has been held in Brussels as well as presentations at the Planet under Pressure conference in London in the end of March 2012. Bothe addressed different components of the products and the results of the project. Further presentations and communications will be done during the year 2012, in the scope of GEOSS as well on a scientific congress (ECOSUMMIT).

c) Direct contact is made with the CBD to share the results of the global environmental stratification

d) Reports and reviews are made for interested scientists, other related EU research project leaders, stakeholders, European and national monitoring agencies, policy-makers, NGOs and international initiatives, such as GEOSS, DIVERSITAS and Lifewatch. Direct communication is sought with the follow-up project EU BON and the results have been presented to them. However, at present it seems that there is only a minor connection between the two projects. Future discussions will show further synergies.

Section B: Contributions to standards

The project intended to deliver standards for biodiversity monitoring and the link between field observation and earth observation. It delivers protocols for habitat monitoring and standard approached for field monitoring. These results have been offered to the EEA, DG Environment and the ETC Biodiversity with the request to develop further the process of standardisation through CEN. No reaction has been received yet.

The results of EBONE allow better exchange between countries and research groups providing harmonised data on European biodiversity. This will enhance modelling at the European level and therefore deliver a better statistically reliable approach for policy support in the field of climate change and biodiversity.

List of Websites:

http://www.ebone.wur.nl