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BIOdiversity Multi-Source Monitoring System: from Space TO Species

Informe

Información del proyecto

BIO_SOS

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Sitio web del proyecto

Proyecto cerrado

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Coordinado por
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Este proyecto figura en...

Final Report Summary - BIO_SOS (BIOdiversity Multi-Source Monitoring System: from Space TO Species)

Executive Summary:
The project titled "BIOdiversity Multi-Source MOnitoring System: From Space To Species" (BIO_SOS) addresses topic SPACE.2010.1.1-04 “Stimulating the development of GMES services in specific areas" with application to (B) BIODIVERSITY.
The main objective of BIO-SOS is the development of a knowledge-based pre-operational ecological modelling system suitable for effective and timely multi-annual monitoring of NATURA 2000 sites and their surrounding areas particularly exposed to different and combined type of pressures. Its input data sources are satellite-based measurements and on-site data. Ontologies and semantic network are used to formally represent the expert knowledge. The proposed system, named EO Data for Habitat Monitoring (EODHaM), is compliant with on-going GEOSS, GMES and INSPIRE initiatives. Study areas in three Mediterranean and two Western Europe Countries are under way. To extrapolate from European test cases such that the methods can be applied more generally, additional areas are being considered in two tropical countries (i.e. Brazil and India), where the Natura 2000 system does not exist, but the availability of advanced monitoring systems is particularly important for Biodiversity conservation. BIO_SOS has developed:
• Novel pre-operational automatic high spatial resolution (HR) and mainly very high spatial resolution (VHR) EO data understanding techniques for land cover/use (LC/LU) map and LC/LU change map generation as an improvement of Copernicus core services;
• New Copernicus down-stream services based on ecological modelling, at habitat and landscape level, to combine EO and in-situ data and provide HR and VHR General Habitat Categories (GHCs) (http://www.ebone.wur.nl) and Annex 1 Habitat maps, their changes and adequate landscape indicators as basis of biodiversity indicators. Target habitats (e.g. priority habitats) can be extracted as binary products.
• Spectral Indices to be used for landscape modelling, such as: NDVI; WBI; PSRI.
• Context features to be used for landscape modelling.
• Quantitative landscape pattern analysis (QLPA) framework to produce composite, site/scale specific indicator set for monitoring and Natura 2000 buffer area identification;
• Ecological niche modelling (ENM) to evaluate the importance of GHCs as environmental variables to explain the distribution of the target species better than LC/LU.

• Pressure/impact analysis framework to use EO data to extract pressure trends through direct detection of their impacts on landscapes, communities and species.
• BIO_SOS metadata geoportal.

The EODHaM proposed system is a 3-stage processing system (Figure 1). It has adopted the Food and Agriculture (FAO) Land Cover Classification System (LCCS) scheme and taxonomy for LC/LU class identification because LCCS is more suitable than CORINE as the land cover/use categories can be more readily translated to habitat categories. EODHaM 1st- stage provides robust classification of bi-temporal radiometrically calibrated EO images into LCCS Levels 1 to 2, with this based primarily on spectral data, followed by a 2nd stage that additionally utilises contextual information to discriminate and map classes in LCCS level 3 and beyond. Based on expert knowledge of botanists, ecologists and local site managers, land cover/use and habitat classes are described by the experts in terms of their temporal characteristics and/or spatial relationships which are used in both 2nd and 3rd EODHaM stages. The outputs of the 2nd stage are LC/LU maps. The outputs of the 3rd stage include General Habitat Categories (GHCs), Annex 1 habitats as well as biodiversity indices and their trends. Thematic change maps are also provided. Once LC/LU classes and habitats are described through a semantic language, any site can theoretically be mapped and subsequently monitored over time.
The expert knowledge classification approach adopted in BIO_SOS strongly involves end users. Consequently, the products proposed will be more familiar to the End Users since they are built on their expertise and can be improved as they further engage with the process.

Project Context and Objectives:
The main objective of BIO-SOS was the development of a pre-operational ecological modelling system suitable for effective and timely multi-annual monitoring of NATURA 2000 sites and their surrounding in areas particularly exposed to different and combined type of pressures. Study areas in three Mediterranean and two Western Europe Countries were analyzed. To extrapolate from European test cases to a general use, additional areas were considered in. Brazil and India, where Natura 2000 system does not exists, but particularly urgent is the availability of advanced monitoring system for biodiversity protection.
Context
Biodiversity and ecosystems integrity are threatened by human activities resulting in pressures and negative impacts (abuses) on the environment. These abuses can occur within the framework or just at the boundary of existing legislation, or be illegal. These type of ecosystem disturbances are often conducted in the period between when an area is selected to become a protected site, and when it is actually so, whatever the protection level applied (a protected area as defined according to IUCN, 2003, or for either a Site of Community Importance – (SCI), or a Special Protection Area – (SPA)), and its consequent inclusion in the European Ecological Network Natura 2000. During this time span, processes of landscape transformation due to, e.g. forest fires, logging, mining, contamination, poaching, spillage of wastes within and in the boundary of such areas, can be common and very fast since these areas are ideal for sheltering these type of activities, because they are generally less densely inhabited and the transition period brings uncertainties. Once the site is protected, harmful activities towards the environment can be pursued (sometimes within the framework of existing legislation as a form of social and political compensation for the usually unavoidable limitations to previous traditional economic activities within the protected sites) in the neighbouring of protected sites especially if these are close to urbanized, touristic and agricultural

areas. Slow processes, such as logging a few trees at the time at the boundary of forest patches or destroying few squared meters of grassland pasture at any ploughing, as well as the construction of road and small houses are very frequent. The cumulate effect of such localised activities through time can lead to habitat loss and fragmentation. Periodic change detection via remote survey might provide precise and quantitative assessment of change at the local scale, thus enabling local authorities for appropriate action. Remote monitoring, which might also be exerted from a delocalized centre, is certainly to be favoured because the control centre itself can be kept save from undue pressures.
In the European Union (EU) there is a legal obligation for EU Member States to report on status and trends of species and habitats of European importance through the Habitats and Species Directive, the Birds Directive and the Water Framework Directive. However, the 2009 summary report on Article 17 of the Habitats Directive concludes that data on species and especially habitats are collected in different ways, are unavailable or are insufficient in their spatial coverage. The reporting obligations for the European Directives are therefore difficult to implement with uncoordinated data. This is particularly the case in Mediterranean countries that typically lack data or those that exist are often of poor quality. To conduct monitoring of species and habitats, internationally accepted indicators need to be used. In particular, 22 biodiversity indicators were suggested by the Convention of Biological Diversity (CBD) in 2006 which are to be reduced in number following the July 2009 workshop summary of the Secretariat of the CBD and the UNEP WCMC
As national and regional differences in policies and funding occur, there is still a lack of:
a) long-term baseline data;
b) standardized, rapid and cost-effective monitoring techniques;
c) methods for assessing the significance of measured changes and evaluating trends;
d) modelling techniques for evaluating the combined impact that different drivers affecting soils and/or vegetation may have on biodiversity in time;
e) adequate communication to disparate, often contrasting, audiences corresponding to different groups of stakeholders.
A further issue is the lack of a centralized management of biodiversity data and land cover change monitoring system, even at the same regional-local level.

The aforementioned factors require a noticeable effort to initiate a continuous, operational and quasi real-time monitoring of the Natura 2000 sites with special emphasis on their boundaries. User's requirements include techniques to make this information processing system operational, namely:
• Work at spatial scales 1:5,000 or finer, where habitats ought to be represented.
• Increase the system degree of automation (ease of use).
• Increase the system computational efficiency.
• Increase the system accuracy.
• Increase the system robustness to changes in the input data set.
• Increase the system robustness to changes in user-defined parameters, if any.
• Reduce the system timeliness (which is the time span between data acquisition and product delivery to the end user; it increases monotonically with manpower).
• Reduce the system costs (e.habitat. by reducing manpower, exploiting open source software solutions, etc.).

Related to the aforementioned operational system requirements, common practice in Earth Observation

(EO) data processing and understanding appears somewhat inadequate. In particular, images from medium (10-30 m) spatial resolution satellites already used in previous FP6 and ongoing FP7 projects are often too coarse for habitat and related pressures definition. Habitat can be inferred to a certain level of approximation. This approximation can be improved using very high spatial and (possibly) spectral resolution images but no historical VHR coverage exists for any site unless by chance. On the other hand, hyper-spectral data useful for species distribution pose the problem of high costs if acquired by airborne platforms. All this, despite its discouraging appearance, offers a way to speed up habitat recognition and pressure identification. The choice of sensor also depends on the size, spatial distribution and the temporal changes in the habitats being observed. Such a way passes through the correct choice of the satellite sensor or set of sensors to use depending on the habitat characteristics that must be detected and at which spatial and temporal scales; automatic radiometric image calibration and the development of reliable and quasi real-time classification and change detection techniques, which should be mainly based on prior knowledge (deductive) learning schemes than data driven (inductive) learning schemes for reducing both the costs required by extensive ground truth collection and delivery time.
A key challenge addressed by BIO_SOS was the development of a cost effective and timely monitoring of changes in the land cover within and along the borders of protected areas to judge the effectiveness in protecting and conserving the regions from human impacts. Habitat maps, which are at the base of indicators extraction can be obtained by integrating land cover maps of sufficient detail with ancillary data, other EO derived products and by re-labelling and, where appropriate, by merging similar land cover classes, according to the 92/43 EEC Directive and to General Habitat Categories (GHCs) based on life forms as defined in previous BioHab project [Bunce et al. 2008]. In this framework, the BIO_SOS working objectives were:
1) To develop novel operational automatic high spatial resolution (HR) and mainly very high spatial resolution (VHR) and hyper-spectral resolution EO data understanding techniques for land cover (LC) map and LC change (LCC) map generation for biodiversity monitoring, as a contribution to the improvement of core service products.
2) To develop a modelling framework at both habitat and landscape level to combine EO and in-situ data in support to the automatic provision of habitat maps, habitats change maps and landscape indicators to be used for biodiversity indicators extraction and, assessment and prediction of the impacts that human induced pressures may have on biodiversity. This led to the development of new downstream services production.

Project Results:
Results.
WP2. USER REQUIREMENT COMPLETION.
•A concise description of all test sites with details on the habitat composition, landscape configuration and the human pressures, impacts and threats on the sites biodiversity. The program examined a wide array of sites (mainly Mediterranean, but also continental and atlantic) with different features ranging from wetlands at coastal sites to inland sand dunes and mountainous sites. The differences and similarities of the sites were presented and analyzed. Also a preliminary search identified the available data and maps for each site, and the possible sources for additional information.

•Established contact and open dialogue with the management authorities responsible for the protected areas we used as test sites in our project. This communication allowed us to extract information on their needs and also to inform them on the potential application of our end products for the more efficient management of the test sites.

•The identification of the end users data needs and requirements was established and the signature of SLAs completed. This WP finalized the BIO_SOS SLAs (Service Level Agreements), which were then signed both by the protected areas management authorities and the BIO_SOS partners responsible for each test site.

•The selection of biodiversity indicators useful for the efficient management of the protected areas. After a careful evaluation of the biodiversity value of each site and the needs of our end users (the management authorities) and taking into account the main impacts and threats of biodiversity in each site, we identified the biodiversity indicators to be extracted. Also the technical details (e.g. data spatial and temporal resolution) regarding the specifications of the end users need were finalized.

WP3. EODHAM SYSTEM AND SERVICE.
The EODHaM System is a set of interacting components forming an integrated whole, that serves all the aspects of the monitoring and surveillance and offers a complete biodiversity monitoring service.
Some notable points of the EODHaM system that characterizes the completeness of success of the system are the following:
•Methodology: The EODHaM system consists of three primary classification stages, with these focusing on Food and Agricultural Organization (FAO) Land Cover Classification System (LCCS) categories and their subsequent translation to General Habitat Categories (GHCs). An object-oriented approach, implemented as open source software, is followed for the extraction of the studied characteristics of the landscape throughout the entire EODHaM system process.

•Flexibility: From the start point of the overall workflow definition of the processing chain, to the last point of domain specific processor customization, the EODHaM System offers maximum flexibility, of service personalization, with aim to satisfy completely the stakeholder request. The BIO_SOS Processing Modules are exposed to the system as web services and can communicate each other with high interoperability. From the general point of view of the EODHaM system, the BIO_SOS Processing Modules are the building blocks of a processing chain, as defined from a work - flow.

•Processing quality: Through the BIO_SOS project, the processing methodology matured up to be systemized, creating qualitative BIO_SOS Processing Modules with elevated accuracy on the extraction of scientific output and dataset production.
•Customization: The high permitted parameterization of the applied processing methods, offers full adaptability, to the requirements of each monitoring area. The strength of this system lies in its flexibility in order to integrate domain specific configurations for processing steps (including the use of specific ancillary data).The monitoring service that is based on this system, takes into consideration these domain specific configurations, integrating thus scientific expertise into an operational work-flow.

•Automation: The execution of one or multiple instances of a defined processing chain is an automatic procedure for the EODHaM system. The various system modules interact and collaborate like well-oiled gears of a machine. The system monitors all stages and executes each task in the specified sequence of the processing chain. The provided datasets are transferred from one BIO_SOS Processing Module to the other automatically as defined on the workflow.

•Collaborative dissemination: The metadata organization, with harmonized description and quality evaluation of spatial data, of the large number of BIO_SOS final or intermediate products, produced in the several stages in the processing chain, has been assigned to the BIO_SOS Metadata Catalogue. The BIO_SOS Metadata Geoportal has been developed as a collaborative platform with functionalities to catalogue all relevant in situ and ancillary data across the consortium, based on a common, ISO 19115 compliant, metadata profile.

•Spatial data quality evaluation: Regarding spatial data quality evaluation, the BIO_SOS Metadata Catalogue Portal, provides a user-friendly interface for users less familiarized with spatial data quality concepts to perform an evaluation of fitness for use of spatial data, based on metadata entries. This component allows the user: (i) to select the context (dataset quality assessment, or dataset search and rank according to quality criteria); (ii) to define the expected data quality values for a set of predefined quality indicators, based on metadata fields that correspond to the values that the user would like the dataset to have; and (iii) to visualize a final summary with the results of the evaluation indicating the conformity or non-conformity of each quality indicator and an overall fitness value for each selected datasets.
In conclusion, the EODHaM system will automatically generate maps of LCCS classes Level 1-3 and 4 as well as associated General Habitat Categories (GHCs) and changes in these and associated counts of features, object sizes and geometries, LCCS class codes and landscape indices. These maps can be integrated within a GIS system and then be used for a wide range of purposes relating to mapping and modelling of flora and fauna distributions, threat mapping (through detection of certain land covers or change) and assessing the short to long-term impacts of change detection.

WP4. ON SITE DATA COLLECTION.
•A standard WebGIS platform and a metadata geoportal and catalog with data quality evaluation modules were developed using open-source software and loaded with more than 800 metadata entries (for pre-existing and new data) during the project operational lifetime. This platform enhanced data and metadata communication and harmonization within the consortium, using current/state-of-the-art protocols and standards (e.g. ISO 19115, ISO 19139, INSPIRE). The internal and external ("fitness for use") quality of pre-existing datasets was assessed within the consortium considering several application contexts. The geoportal will be made available as an outreach product of the BIO_SOS project and it has also been extended with an communication interface for integration with other modules within the EODHaM system.

•The criteria underlying the specification of EO data for protected area monitoring were specified and linked to the objectives of habitat and biodiversity monitoring. This activity and the corresponding deliverable resulted in the publication of a review paper that is expected to have a high citation potential in the field of remote sensing applied to ecological and environmental monitoring.

•Links with previous and on-going projects such as EBONE, MS.MONINA and EU BON have been firmly established and resulted in close cooperation. Several joint organisations with MS.MONINA allowed a rather coherent dissemination of results from both projects. In GEO-BON, the representation of BIO_SOS has been established in the steering board.

•The identification of the system's data needs and requirements was established to support an adequate choice of field protocols and the implementation of a suitable and cost-effective sampling strategy. This WP established the BIO_SOS field sampling strategy for in-field collection of data relating to General Habitat Categories (GHCs) as well as to pressures, flora, fauna and soil data relevant to WP5, WP6 and WP7 tasks. This WP also contributed to the description of the protocol for accuracy assessment of the thematic maps generated from the EODHaM system, and examples for the instantiation of such a protocol were provided.

•Several training sessions on field protocols were held in different countries to ensure a standard application of concepts, methods and protocols. New datasets were collected from the several sites through new in-field campaigns, from land cover and habitat data for system training and validation, to data on pressures, biodiversity indicators, community structure and other proxies for modelling and monitoring habitat quality and change detection.

WP5. EO DATA PROCESSING MODULES IMPLEMENTATION.
•Establishment of a framework for standardised classification of land covers at multiple spatial resolutions and observation modes. A new and innovative approach to standardized mapping of land covers using primarily earth observation data has been designed and brought through to practical implementation within an open source environment. The system anticipates calibrated data (e.g. to top of atmosphere or surface reflectance, radar backscatter coefficient, lidar-derived surface height), which are used for feature extraction followed by segmentation and subsequently for classification to LCCS Level 3 and Level 4. The latter are translated subsequently to GHC and then Annex I categories.

•Development of innovative feature extraction and segmentation algorithms. To divide the landscape into recognizable units that can be described using semantic terminologies, the concept of small (e.g. trees, buildings) and large objects (field units) has been adopted within the EODHaM system. New techniques for extracting these objects from the image data themselves have been developed with the algorithm of Shepherd et al. (2013) available within RSGISLib (Bunting et al, 2013) utilised for segmenting the remaining areas.

•Identification of data input requirements. The BIO_SOS project has established the minimum optical data requirements for classification of vegetated environments based on the LCCS taxonomy to be pre or post-flush and peak flush images required for areas with more seasonal environments depending on day length (spring, summer) or precipitation (wet, dry). For environments with varying hydrological regimes, the optimal dates should correspond to high or water flow conditions. Observations during transition periods benefit the differentiation of LCCS categories.

•Identification of classification inputs. For assigning classes within the different LCCS levels a rule-based approach is currently used. Key indices for classification of photosynthetic, non-photosynthetic vegetation, water and wet areas, and woody vegetation within the a rule-based have been identified. Alternatively, individual classes can be extracted from other classification outputs.

•Innovative approaches to change detection: Four distinct methods for the detection of change have been identified, with these based on the comparison of a) features, b) object size and dimensions (merged, split or stable), c) the components of the LCCS codes and d) the image data themselves (e.g. reflectance) or derived indices. Links have been made with the EU FP7 COBWEB project which is seeking to use crowd sourcing to collect information on the change metrics which can be used to support validation of the EODHAM products.

•Demonstration of application to multiple environments. Throughout the project period, the EODHaM system has been developed such that it encompasses a diversity of environments. LCCS and GHC maps have been generated for sites in Italy, Wales (UK) the Netherlands (on which the method was developed initially) and then applied to Portugal, Greece, India and Brazil. Change detection methods have been demonstrated for sites (e.g. Wales, Italy) for which dual season imagery had been acquired in two separate years.

•Links with users. Throughout the development period, links have been established with the local users (e.g. Countryside Council for Wales, Puglia Regional Authority) such that validation data and informative decisions have been provided. In Wales, for example, the technique is being evaluated on other Natura 2000 sites distributed across the country.

•Links with scientific users. EODHaM Classification software available in open software (python). EODHaM system can be set up as a “Virtual Machine” (to be implemented in different platforms (Windows, Mac, Linux). Scientifc users can test EODHaM system on different sites and contribute to system generalization.

• Ontological description of land cover and habitat classes. We extended the OBOE (Extensible Observation Ontology) top-level ontology initially designed for the description of scientific observations. We applied it for describing land cover and habitat classes as defined in the LCCS and GHC taxonomies.

•Ontological interpretation of remote sensing images. The OBOE ontology was also extended to describe image objects, based on image properties such as radiometry, texture, shape... We thus produced semantic description of remote senisng images and we used an inference engine (Fact++) to assign each image objects to geographic concepts.

•Ontology matching to translate LCCS to GHC. LCCS and GHC ontologies were matched based on the identification of key correspondences between both taxonomies. We were then able to use inference engines to ensure conversion from LCCS classes to GHC classes, and vice-versa.

WP6. EODHAM MODELING MODULES DEVELOPMENT.
•Provided a qualitative-quantitative comparison of habitat classification systems and land cover taxonomies for habitat monitoring in Mediterranean areas that is without precedent in the literature.

•Compared to other LC taxonomies, LCCS turns out to be the best candidate to cope with the complexity of habitat description as it allows for a more precise land cover class definition of natural and semi-natural types. LCCS provides a framework for EO and in situ data integration for habitat mapping and for long-term monitoring of their conservation status.

•Developed and successfully tested a framework for identification of site and scale specific indicators of habitat fragmentation from LCCS maps, to quantify historical habitat fragmentation trends and for scenario analysis of future management and climate impacts
•Demonstrated the usefulness of VHR EO data as proxies for indicators of biodiversity surrogates (especially functional groups) and explored their inferential potential towards landscape and habitat structural characteristics, as required for monitoring.

•Explored a framework for landscape functional connectivity modelling using Environmental Niche Models and based on both Graph Theory and existing field data for a species of conservation concern.
•Demonstrated the importance of Ecological Niche Models for linking habitat maps derived from Earth Observation data with biodiversity distributions in the field with studies in Italy, the Netherlands and India
•Developed a model for scenario analyses relative to water and sediment flux connectivity and harvesting, and corridor size with predator-prey dynamics, enabling examination of the internal robustness of ecosystems and its susceptibility to external pressures .
•Systematized analysis of frameworks to assess pressures on protected areas, using these to develop an EO data-based framework for monitoring pressure-derived impacts on land cover/habitats, communities and species.
•Implemented for the first time (based on work on habitat modelling) , a detailed framework for the production of GHC from LCCS maps and the translation of LCCS and GHC to Annex I classes
•Investigated the potential of texture analysis measures in vegetation height estimation
•Systematized analysis of existing frameworks to assess pressures on protected areas, using these to develop an EO data-based hierarchical system for monitoring pressure-derived impacts on land cover/habitats, communities and species. The system refers to impacts which can directly or indirectly be evaluated by means of EO derived products (maps, features) through landscape or habitat modelling implemented.

WP7. EODHAM ANALYSIS OF DIFFERENT SAMPLING SITES AND VALIDATION.
Portugal: Baixo Sabor (PT1-N Remondes and PT1-S Felgar)
•Classification complete for Baixo-Sabor (PT1) up to LCCS Levels 4. An approach to retrieve urban features and cadastral boundaries form the image itself has been successfully applied. Refinements were carried out to maximise the diversity of classes generated but the number of classes able to be discriminated was limited by the timing of the observations (many areas supported non-photosynthetic vegetation) and also shadowing in the post-flush imagery. Translation to GHC has been implemented. The approach to change detection is available for use with the Portugal site.
•Note that classifications to Level 4 have been generated for Felgar and Remondes but with varying degrees of accuracy. Translation to Annex I has also been implemented although a number of options were generated. Cadastral and urban information was extracted from the image data themselves.

Portugal: Peneda-Gerês (PT2N Castro-Laboreiro and PT2S Vilar da Veiga)
•On PT2N Castro-Laboreiro: Classification Levels 1-3 complete for Castro-Laboreiro (PT1) and has been extended to include Levels 1-4. Translation to Annex I has not been implemented since the rule set was provided late. Cadastral and urban information was extracted from the image data themselves.

•On PT2S Vilar da Veiga: No classifications were generated because not enough VHR Optical Data were acquired.

Greek site: Kalamas Delta (GR1)
•For the Kalamas Delta site, the classification of LCCS categories at Level 3 and Level 4 was improved using the EODHaM system and using standard datasets (e.g. NDVI, PSRI and WBI). These classes were translated to GHCs with ambiguities resolved and also to Annex I classes.
In D7.3 the EODHAM system was applied to the sites in both Brazil and India. The translation to GHC was achieved as the classification was relatively simple and focused primarily on forest classes (GPH, FPH etc.) and graminoids (CHE) but and Annex I was not undertaken as such habitats are not categorized.
•Brazil - Tapajos Forest (BR1). For the Brazilian site, the use of single date imagery was sufficient for classification because of the lack of seasonal differences in the vegetation. However, dual season imagery was essential for differentiating the main forest types at the Indian site.

•India (IN1 site). LCCS 1-4 classification and translation to GHC were achieved as the classes were relatively simple and focussed primarily on forest classes and graminoids. Since a GHC former map does not exist for comparison, it was difficult to validate the current one.

•For the sites in Italy, Wales and the Netherlands, the EODHaM system was developed and implemented to generate classifications of LCCS Level 4 categories with associated information on GHCs and Annex I habitats where the latter were sufficiently distinct.

•Wales was considered a training set, as well as Le Cesine and Murgia Alta site. In all cases, dual season imagery acquired in the pre- and peak-flush periods was needed and a Lidar-derived CHM (available for all sites) allowed better discrimination of the vegetated areas and between lifeforms (trees and shrubs). For some sites, additional images (dry season and post-flush) were used. Validation of the mapping was achieved in some cases, which suggested a broad correspondence with the land covers and habitats occurring but variable levels can be expected depending upon the complexity of the landscapes being classified.

WP8. DISSEMINATION, EXPLOITATION AND OTHER.
• The website was designed, regularly updated and renewed (http://www.biosos.eu/).
• Publications and dissemination activities are available on the web page. An intranet section with agenda and presentations of BIO_SOS technical meetings is available.
•Clear links have been established with relevant groups such as DG ENV, EEA & ETC, EIONET/NRCs, national EPAs, ENCA and stakeholders operating at the European level to pass the message on project content & purpose, and receive input for project how to align e.g. with national reporting. The participation to international workshops (project meetings) and direct contacts were at the base of such activity. Presentations have been held in several occasions. A meeting has been held with GEOBON in Geneva.
•Constant contact with users, e.g. EEA, HARMBIO (COST), COBWEB project.
•Communication on results at European and National level.
•Technical communications with EEA, DG Env, DG RTD and GEO on LCCS
•Technical communications with EEA, ETC-BD on GHCs
•Communication with local stakeholders is ongoing.

•Several user training sessions have been held (UK,NL, I)
•The BIO_SOS user manual was finalised in the last months.
•Organization of two joint session with MS.MONINA project:
•GI Forum, combined session of MS.MONINA and BIO_SOS, Date: 1-4 July 2013, Salzburg
•Final Symposium at: IALE European Congress; Date: 12-16 September 2013, Manchester
•Two policy briefs have been published and are available for use. They contains main results, services and the partner overview and contact details.
•Data and interpreted files can be shared by partners (GEO-portal, KEA grid files)
•EBONE database and field computer software available through the GEO-portal.
•The management of IPR issues has been discussed.
•A training/dissemination session was held in India in August 2013.

Potential Impact:
The EU responded to the recognition that the biodiversity target 2010 would not be met, despite some major successes (Natura 2000), and the adoption of a global Strategic Plan for Biodiversity 2011-2020 at the tenth Conference of the Parties (CoP10) to the Convention on Biological Diversity (CBD), with the "EU biodiversity strategy to 2020 ". The EU Biodiversity Strategy also contributes the EU Strategy 2020, the EU's growth strategy for the coming decade where six main targets are established: Employment, R&D and Innovation, Climate Change and Energy, Education and Poverty and social Exclusion (source: BIO_SOS and MS_MONINA white paper, January 2014).

The Strategy's main target is to halt biodiversity loss and the degradation of ecosystem services in the EU by 2020. To meet this target several sub-targets and actions. Particularly, BIO_SOS and MS.MONINA project results can help to comply with the actions under Target 1 "to fully implement the Birds and Habitats Directives". Additionally, the projects may support action 5 (Mapping and Assessment of Ecosystems and their services), action 6a (set priorities for ecosystem restoration) and 6b (Development of a Green Infrastructure Strategy 2012).

In the European Union (EU), the Habitats Directive (92/43/EEC) and the Birds Directive (79/409/EEC) oblige Member States to report on the conservation status of species and habitats of European importance every six years and trends in status in the intervening period. However, as reported by the Topic Centre on Biodiversity, data on species and especially habitats are collected in different ways, are unavailable, or are insufficient in their spatial coverage. For these reasons, the development of a uniform observation system that can be easily used by all Member States for reporting obligations and defining management strategies (either strategic or operational) is very important. This is particularly the case in Mediterranean countries, which typically lack long-term baseline data for assessing changes and evaluating biodiversity indicator trends.

BIO_SOS has made progress steps towards developing an operational system for effective and timely monitoring of NATURA 2000 sites and their surroundings in Europe. At global level, some biodiversity hotspots have been considered in Brazil and India, where the Natura 2000 system does not exist, but the availability of advanced monitoring systems is particularly important for Biodiversity conservation. As far BIO_SOS is aware, in both Countries there are no policies as compared to the Habitats Directive that require monitoring for habitats or land cover categories. There are some individual requirements for specific parks implemented at different points in time by administrators in India. In Brazil, there are different types of protected areas: National Forest, indigenous land, conservation unit, sustainable reserve, Environmental Protection Area (APA). Each one has its own specificities and their combination forms a mosaic of protected areas.

In this framework, the major impact of the BIO_SOS project can be described as follows. The BIO_SOS project is offering a methodology to support Member States in their obligations:
•The Earth Observation Data for Habitat Monitoring (EODHaM) system developed by BIO_SOS has the following peculiarities:
1) The same methodology is adopted for the monitoring of the different Natura 2000 study sites.
2) EODHaM is based on a knowledge driven (rule based) classification scheme which is particularly useful to monitor large or not accessible protected areas as no ground truth is required to train the system. Based on expert knowledge of botanists, ecologists and end local site managers, the EODHaM system is able to integrate Very High Resolution (VHR) and High Resolution (HR) Earth Observation data and on-site data. The knowledge base approach, adopted in EODHaM, focuses mainly on three components: a) prior spectral knowledge for automatic preliminary EO data analysis; b) temporal (phenological) relations for the selection of the EO acquisition months most useful for class discrimination; c) spatial relations to be used for context-sensitive feature selection and subsequent class discrimination. As an example, spatial reasoning on clouds and their associated shadows can also permit to disambiguate clouds and bare soil in one hand; prior knowledge on agricultural practices can be used to discriminate natural forest from permanent crops (characterized by oriented texture) and, within permanent crops, olive trees from orchard and vineyards in VHR images. The method allows the description of a specific habitat to be generalized so that habitats can be automatically identified when different sites and conditions are encountered. Consequently, the products proposed by BIO_SOS, such as updated land cover/use maps, habitat maps and landscape indicators, will be more familiar to the end-users since they are built on their expertise and can be improved as they further engage with the process.
3) The Food and Agricultural Organisation (FAO) Land Cover Classification System (LCCS) is used for LCLU classes taxonomy. Compared to other LC taxonomies, LCCS turns out to be the best candidate to cope with the complexity of habitat description as it allows for a more precise land cover class definition of natural and semi-natural types. LCCS provides also a framework for EO and in situ data integration for LCLU to habitat translation and for long-term monitoring of habitat conservation status, as whitin class changes can be easily detected. FAO-LCCS is based on the concept of Life-Forms.
4) The BIO_SOS habitat mapping procedure is based on the automatic identification of LCCS classes, with these translated in General Habitat Categories (GHCs) and then in Annex I or directly in Annex I habitats depending on the availability of ancillary in-situ data (see Deliverable D6.10). Both LCCS and GHCs classes 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 and then to be translated in Annex I through the rules reported in the EBONE handbook and adapted to BIO_SOS sites (within D6.10). In addition, GHCs map can be used as basis for identifying habitats outside Europe, such as in India and Brazil, where Annex I list is not adopted and habitats are described in terms of life-forms terminology. However, regular collection of mainly VHR EO data on Natura 2000 network is mandatory to detect changes and trends over time at fine scale, as required by the end users. As well-known, HR data (e.g. new LANDSAT 8, future Sentinel 2 data) cover all the globe, but ecological processes need to be

monitored at a different spatial resolution (grain), including VHR (<4m.). At the same time it must be mentioned that VHR EO data cannot always help in mapping and monitoring of specific habitats, since some of them can only be detected in the field (including their quality). However we demonstrated that this can be inferred using EO features, from both the relationships emerging with biodiversity surrogates (habitat modeling) and with landscape descriptors (landscape modelling).
Certainly more research is need on this but, we are in the position to suggest that such an approach can be considered for application at large scales (regional or continental) based on extrapolation from validated sample localities. Moreover, terrain managers and surveyors are very happy with support on the monitoring of larger habitats and species that are very dominant, so that field work can be more targeted on specific phenomena. This will lead to efficiency in resources in the end.
In addition, for validation purposes the collection of reference ground truth data to be explicitly labelled according to both CORINE and FAO-LCCS taxonomies is requested. Such data will be very useful for CORINE to FAO-LCCS translation when pre-existing LCLU validated map in CORINE taxonomy are available and would be used for change detection in comparison with updated LCLU map in LCCS taxonomy from EODHaM.

• EODHaM offers the opportunity to map the whole site extent automatically from EO data without the need of in-field campaigns. EODHaM procedure can provide both VHR maps for regional/local services and HR maps. Consequently, the system helps to reduce the cost of habitat mapping and monitoring significantly for medium-large and/or not-accessible sites and can reduce the need for and steer the focus of in-field campaigns significantly as ground reference data are only required for product validation. This helps to make monitoring of changes feasible at a larger extent than currently possible due to budget limitations of park administrations and/or other competent entities. The translation of LCLU maps to Habitats maps requires the integration of LCLC maps with in-situ environmental data (e.g. water salinity in wetland sites, lithology, soils aspects, etc.). Such data have to be provided by Member States (e.g. Management Authorities). The estimated costs of the service, including costs for including costs for work, computer, storage, backup, execution and quality control, is about: a) 10-15 EUR /sqkm for a minimum of 200 sqkm at 2m. resolution; b) 1-1,5 EUR /sqkm for a minimum of 2000 sqkm at 30 m resolution. The cost of the images and ancillary data are charged on the users.

•EODHaM provides a standardized classification framework that was mainly applied to VHR imagery (e.g. WorldView2 and QuickBird) but is extensible across multiple sensors, as done for the Brazilian site with Landsat data. Using the EODHaM system, classifications of FAO LCCS categories and their subsequent translation to GHCs and Annex I categories can be undertaken for any site worldwide given availability of appropriate input data. The application of the EODHaM system in Brazil and India demonstrated that the system can be adapted to tropical sites. Moreover the study has underlined the need for adapting the GHC categories description to subsequent local habitat categories translation. The EODHaM processing chain will give huge advantages in case of a continuous data flow from Sentinel-2. It has to be yet assessed, what level of accuracy the EODHaM system will be able to deliver for Sentinel-2 data, but the huge advantage would be to be able to raise the accuracy of LCCS class detection through a higher multi-temporal resolution through the year in order to better capture the different vegetation cycles, when needed for improved vegetation class discrimination at low cost.

The ecological modelling framework developed in BIO_SOS, at both habitat and landscape level, can support scenario analysis. A series of frameworks based on free software was provided which demonstrate the usefulness of EODHaM products for landscape modelling linked to biodiversity monitoring. Provision of key methodological issues related to the context-specific implementation of such frameworks will enable regional authorities and site managers to make appropriate choice of existing tools in connection with their needs and data availability. Some tools (i.e. r.sim.road and LANDPLANER) are fully parameterized and use LC as main inputs. These allow managers to perform scenario analyses of water/sediment connectivity leading to gully development and generation in sensitive areas, induced by pressures due to external drivers. This impacts on planning of ecosystems conservation and restoration actions. In addition, the simulation of the wolf - wild boar dynamics in fragmented areas gives insights on the degree of fragmentation that allows the permanence of wolves in protected areas (critical patch size). It may also be exploited in a wild-boar population control program to reduce agricultural damages. Both these models work on physical areas larger than the protected areas and both can identify pressures originated physically outside the protected zones. LANPLANNER (and r.simroad) covers the whole hydrological basin which the protected area belongs to, identifying activities and land use changes that can influence the water and sediment budget inside the protected areas. R.simroad brings partly in the effect of infrastructures planned outside the protected area. Hence they have and impact also on the definition of the belt-area that must be checked to keep the integrity of the protected area. EODHaM habitat maps (and particularly GHC maps) play a crucial role in enhancing the quality and explanatory power of Ecological Niche Models and of graph theory and movement based functional connectivity models. These kind of habitat maps are the key to switch from theoretical spatial explicit models which, in turn, are essential to inform stakeholders (e.g. managers, NGO) on potential impacts on species distribution and landscape functional connectivity driven by changes in LCLU. The habitat maps derived by EO systems demonstrated the importance of Ecological Niche Models for linking habitat maps derived from Earth Observation data with biodiversity distributions in the field.

•The proposed standard protocols for sampling design, accuracy assessment and in-field campaigns will provide an efficient, standard methodology for input data collection for system validation as well as for Biodiversity indicator extraction. This is an important component of the novel EODHaM system and it is due to guide managers and practitioners in performing choices in a monitoring context.

•The BIO_SOS Metadata Geoportal is available online as an outreach product of the project, providing access to the updated metadata catalogue. The development of standardized methodologies for external quality evaluation (“fitness for use”) will benefit the quality control of spatial data and products in future projects. Thus, data quality evaluation tools will become available for all users of spatial data concerned with geospatial data quality. This will promote quality evaluation in all applications of spatial data in ecological and environmental assessments, thereby contributing for political and technical decision based on high-quality products.

•The project has resulted in advances in technical knowledge and provided operational open source tools for site managers, researchers and policy makers to implement adaptive management and enhance conservation of natural resources. Consequently, the EODHaM system will strongly support reporting for the Convention of Biological Diversity (CBD), the European Biodiversity Strategy and the Habitat Directive by making the information directly compatible and so will become central to the whole process of managing biodiversity in Europe. The system will allow to unravel certain patterns and processes that were formerly not well understood. This information can then be used to adjust or fine-tune existing conservation objectives, especially in the Mediterranean areas but also outside Europe where the Habitat Directive is not in use but conservation measurements are urgent.

•The project results have been disseminated in different national and international conferences, workshops and have been also published in high-profile international journals, thus providing an important summary of information for managers and researchers to enable better use of EO data for monitoring and management of protected areas and their surroundings. In addition, the collaboration with end users, namely the test sites management agencies contributed to the outreach of the project. Through some workshops and personal communications the Consortium interacted with the management agencies responsible for each test site contributing to the dissemination of the project as well as building a base for future uses of project results.

•In India, a dissemination/training workshop was organised in Bangalore. The classification based on VHR data for the Indian site was very well received and appreciated. Participants were from diverse groups and contributed greatly to identify the implications of this type of research in India. The workshop highlighted the intense need for accessibility and use of VHR data in India in support to conservation policies. In addition the dissemination workshop helped to highlight the benefits of the object oriented method proposed in BIO_SOS and to communicate the tremendous potential it has to the larger scientific community, students, as well as possible practitioners in the fields of biodiversity conservation in the areas of research as well as implementation.

•The close cooperation with on-going projects, especially MS.MONINA has improved the outreach of BIO_SOS. Project results have been presented at three joint workshops (i.e. the G.I. forum in Salisbury, the dedicated symposium at the IALE 2013 congress and the last workshop with end users held on November 2013 in Brussels) provided the necessary platforms to disseminate the Copernicus services offered by the complementary methodologies developed in the BIO_SOS and MS.MONINA projects to support Natura 2000 management authorities, policy makers and civil society. The links with GEO-BON have made it possible for BIO_SOS and MS.MONINA results to be considered at the global level.

•Within international initiative such as the Global Earth Observation System of Systems (GEOSS), conceived by the Group on Earth Observations (GEO) and Copernicus, BIO-SOS has developed a pre-operational system which can provide improved core service products (i.e. VHR LC maps and LC change maps) and new downstream services (i.e. habitat maps as Annex I and GHCs, habitat change maps and landscape indicators).

•The EODHaM system has been adopted by the recently funded FP7 COBWEB project (http://cobwebproject.eu/project) which will explore the possibilities of crowd sourcing techniques around the concept of “people as sensors”, to contribute data for use in policy formation and governance. Particularly, the use of mobile devices will be developed for data collection useful for validating EODHaM products on protected areas.

A detailed list of the dissemination activities is reported in Template A1 and A2.

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