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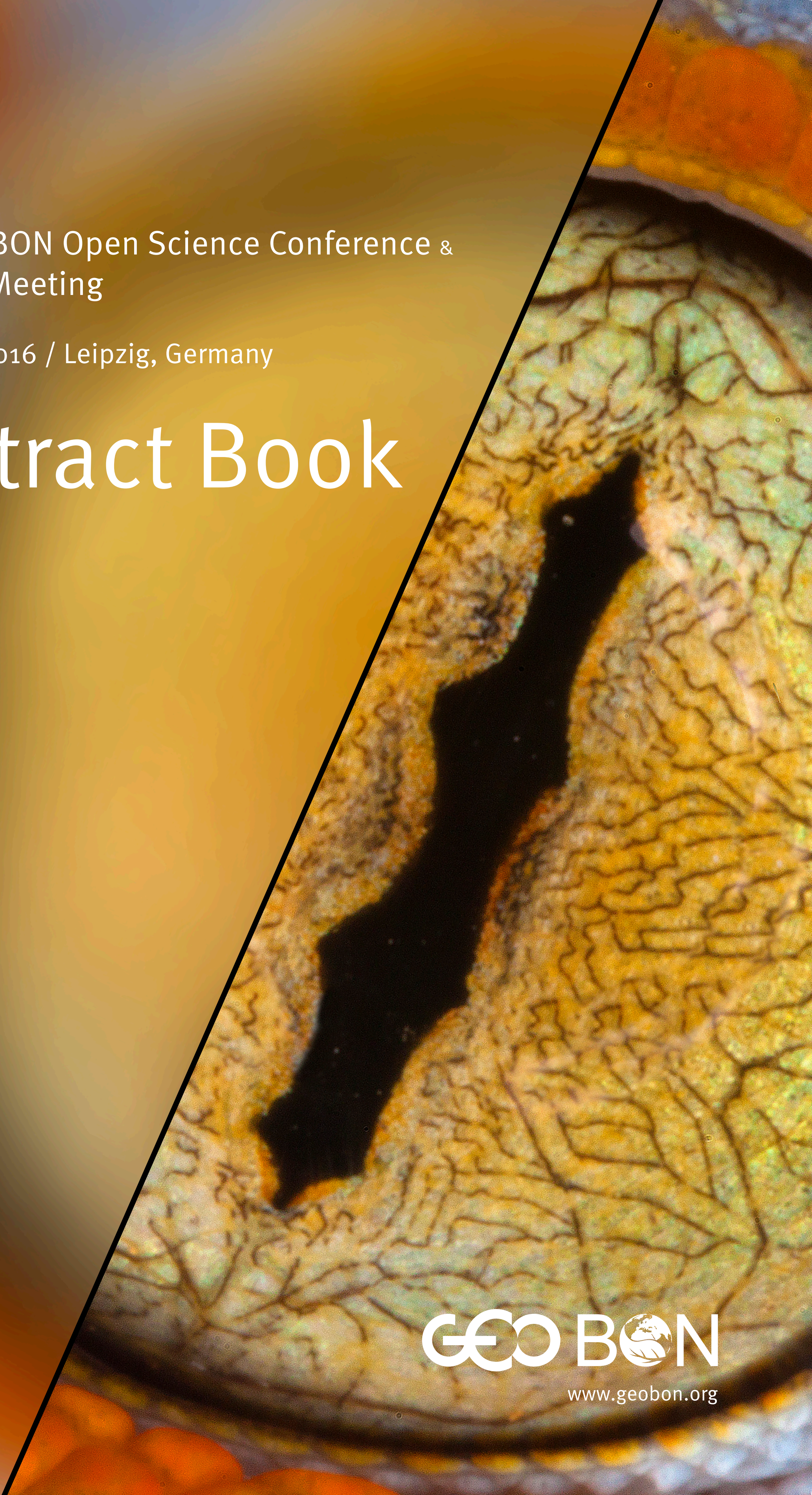
# Abstract Book



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## Remote Sensing of EBVs

### S1.1: Framing the concept of satellite remote sensing essential biodiversity variables: challenges and future directions

**Nathalie Pettorelli**

Although satellite-based variables have for long been expected to be key components to a unified and global biodiversity monitoring strategy, a definitive and agreed list of these variables still remains elusive. The growth of interest in biodiversity variables observable from space has been partly underpinned by the development of the essential biodiversity variable (EBV) framework by the Group on Earth Observations – Biodiversity Observation Network, which itself was guided by the process of identifying essential climate variables. This contribution aims to a vance the development of a global biodiversity monitoring strategy by updating the previously published definition of EBV, providing a definition of satellite remote sensing (SRS) EBVs and introducing a set of principles that are believed to be necessary if ecologists and space agencies are to agree on a list of EBVs that can be routinely monitored from space. Progress toward the identification of SRS-EBVs will require a clear understanding of what makes a biodiversity var able essential, as well as agreement on who the users of the SRS-EBVs are. Technological and algorithmic developments are rapidly expanding the set of opportunities for SRS in monitoring biodiversity, and so the list of SRS-EBVs is likely to evolve over time. This means that a clear and common platform for data providers, ecologists, environmental managers, policy makers and remote sensing experts to interact and share ideas needs to be identified to support long-term coordinated actions.

### S1.2: Methods for bridging spatial and temporal limitations of satellite data to monitor forest disturbances

**Michael Foerster[1];** Philipp Gaertner[2]; Birgit Kleinschmit[2]
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Forest disturbances — caused by drought, fire, storms, fungi and insect pests — lead not only to economic losses but also have numerous environmental impacts. Remote sensing has long been seen as a useful tool for large scale monitoring of their effects and serves as an early warning system. In a variety of cases, the spatial and temporal patterns of these disturbance effects start with a slow intensity dispersion, followed by rapid defoliation and regeneration. Therefore, fine-scale monitoring and operational planning rely on high temporal and spatial resolution imagery. Although the Landsat suite of sensors are often seen as sufficient in terms of temporal coverage, the 30m spatial resolution limits its applicability for fragmented forests, while other sensors such as RapidEye have a higher spatial resolution of 6.5m.
The aim of the presented study is to show the advantages of the data fusion method STARFM

and the time-series analysis tool BFAST to bridge the temporal and spatial gap of the satellite systems available. Additionally the forest disturbances can be related to external factors, such as water availability.
Our study focused on the last 321 km, the area of the lower reaches of the river Tarim in northwest China. The region is characterized by an extreme arid climate with mean annual precipitation less 50 mm and potential evaporation greater 2,000 mm per year. The region is dominated by open sandy areas with dense clusters of young Populus euphratica trees along the riverbanks and sparse isolated withered trees towards the desert. The most common shrub species in the area belong to the Tamarix genus. Predominant herbs and grasses are Karelina caspica, Alhagi sparsifolia and Phragmites australis. All species, in the so-called Tugai vegetation, are drought-enduring and salt-tolerant. The groundwater regime is regulated by the Tarim river discharge which drives the region's ecology including vegetation responses to soil water availability.
In a first attempt we applied the Enhanced Spatial and Temporal Adaptive Reflectance Fusion Model (ESTARFM) to downscale Landsat 8 Normalized Difference Vegetation Index (NDVI) scenes to concurrent RapidEye NDVI scenes to derive a data-set of high spatial and temporal precision. The result could be used to detect forest disturbed by the insect Apocheima cinerarius with the help of the synthetically generated images at the spatial resolution of RapidEye and the additional temporal resolution of Landsat 8.
In a second attempt, we assessed the usefulness of the bfast algorithm in conjunction with a 16 day Landsat NDVI time series to map long term trends and abrupt changes between 2000-2013 with special attention on the effectiveness of an ongoing ecological restoration program. In particular, we addressed the possibility of the trend analysis to characterize abrupt and gradual changes by deriving the time and magnitude of abrupt, and the slope of gradual changes. Moreover, we compared emerging breakpoints between occurring Tugay vegetation classes and determine differences among them and related the timing of detected breaks to periods of known water deliveries.
The outcomes show that data fusion methods and time-series analysis tools can be used to detect trends in forest disturbance and restoration. Moreover, links to external influencing variables can be established. Different EBVs for ecosystem structure and function are addressed in this examples.

## S1.3: Linking plant strategies types (CSR) and plant traits derived by radiative transfer modelling (PROSAIL)

**Teja Kattenborn;** Javier Lopatin; Fabian Faßnacht; Sebastian Schmidtlein

The widely established CSR-model quantitatively groups plants according to their ecological response, i.e. competitiveness, stress-toleration and ruderality. These plant strategies are commonly allocated using plant traits.
In remote sensing plant attributes are most frequently extracted using statistical models, calibrated using prior acquired field samples. A physics-based alternative is given by the inversion of radiative transfer models (RTM), which mimic the interactions of remotely sensed reflectance and plant properties using cause-effect relationships.
Accordingly the present study assesses the potential of using canopy traits derived by imaging spectroscopy and inverted radiative transfer models for allocating CSR-scores. The study area is located in a raised bog vegetation in the Murnauer Moos, Germany. The dataset comprises CSR-

scores derived from species abundances as well as hyperspectral imagery (Hymap). The inversion of the RTM (PROSAIL) was performed using a LUT-approach and estimating Leaf Area index, Specific Leaf Area, leaf chlorophyll content, leaf carotenoid content and hot spot parameter. Relationships between plant traits and strategies were analyzed using correlation coefficients as well as ternary plots. We demonstrate that the expected plant traits of C, S, and R strategies are indeed found by inverse modeling. Hence, RTMs allow to readily map 'soft traits' which can be used to describe the different axis of primary plant strategies (CS, RC, RS).
Moreover, the demonstrated correspondence between patterns of physically derived plant traits and C,S and R strategies further evidences the plausibility of CSR strategies.
Future research will include datasets with increased gradients (especially regarding ruderals) and further traits derivable by remote sensing (e.g. canopy height, seasonality).

## S1.4: Iterative design of an integrated geographic database for species distribution models: the ecotopes

**Julien Radoux[1];** Jessica Delangre[2]; William Coos[2]; Marc Dufrêne[2]; Pierre Defourny
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Ecotopes are the smallest ecologically distinct landscape features in a landscape classification system. In order to derive meaningful ecotopes, it is therefore necessary to assess their fitness to purpose through the analyses of the resulting ecological models. In this study, we present a framework to automatically extract and characterize ecotopes based on multisource information. This work has been conducted in parallel with species habitat modelling and biotope classification in order to increase the relevance of the proposed geographic data model.
The study area is the Walloon Region (about two third of Belgium), which is a very fragmented landscape belonging to the Atlantic and Continental regions. A data model was designed to represent the ecotopes in a geographic polygon database with quantitative descriptors of the land cover. Ecotopes were automatically delineated using 2 m resolution aerial images and LIDAR data in order to extract spectrally and topographically homogeneous units. Ecotopes were then characterized using the main input layers as well as lower spatial resolution images including Sentinel-2 and Landsat-8 data in order to achieve a high (>80%) thematic accuracy on eight land cover classes. The ecotope data model was iteratively tuned based on the needs of the ecological models, and abiotic descriptors were combined with remotely sensed data in order to achieve high prediction accuracy.
The results show that the use of ecotopes improves the predictive ability of ecological models. Those ecotopes can be automatically derived by Geographic Object-based Image Analysis even in fragmented landscapes. Ecotopes could also be relevant to quantify ecosystem services. However, understanding the limitations of remote sensing and integrating ancillary data are keys to achieve optimal model performance.

## S1.5: Globally consistent land cover and land cover change map

**Céline Lamarche;** Julien Radoux; Inès Moreau; Nicolas Matton; Sophie Bontemps; Pierre Defourny
Université Catholique de Louvain Belgium

Land cover change change is, along with climate change, one of the the main drivers of biodiversity change in the world. In the frame of the ESA Land Cover CCI project, a continuous time series of 15 years of Earth Observation data has been analysed to provide a globally consistent land cover map at 300 m resolution as well as consolidated change for each year. Primarily designed for the climate change community, the global land cover map can also be used for natural ressource and ecosystem monitoring thanks to its large thematic precision (22 classes). Furthermore, the full dataset includes three additionnal land surface dynamic products (snow cover extent, vegetation greenness an fire event probability) that provide information about ecosystem functionning.

This presentation will focus on the thematic classes described in the global land cover map, which are defined based on the FAO Land Cover Classification System. The first results of the 15 global land cover change analysis will also be presented and the change dynamics around biodiversity hotspots will be discussed.

## S1.6: Tandem-L: Global Observation of Ecological Processes on the Earth's Surface with Two L-Band SAR Satellites

**Andreas Huth[1];** Rico Fischer[1]; Friedrich Bohn[1]; Nikolai Knapp[1]; Sebastian Lehmann[1]; Edna Roedig[1]; Irena Hajnsek[2]; Kostas Papathanassiou[2]
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Tandem-L is a proposal for a highly innovative L-band SAR satellite mission for the global observation of dynamic processes on the Earth's surface with hitherto unparalleled quality and resolution (10 m). Main mission goals are the global measurement of 3-D forest structure and biomass for a better understanding of ecosystem dynamics and the carbon cycle, and high-resolution measurement of variations in soil moisture close to the surface. In addition the satellite mission can be used for systematic recording of deformations of the Earth's surface for earthquake research (with millimeter accuracy) and quantification of glacier movements and melting processes.

For this mission different bio/geo-physical information products have been developed and evaluated based on a larger number of field campaigns in the HGF Alliance "Remote Sensing and Earth System Dynamics" (EDA) . The presentation will give an overview on the Tandem-L project and main results of the field campaigns concerning forest structure, biomass, forest fragmentation and soil moisture.

## S1.7: Remotely-sensed Ecosystem Functional Types: monitoring functional diversity at the ecosystem level

**Domingo Alcaraz-Segura[1];** José M. Paruelo[2]; Camilo E. Bagnato[2]; E. Hugo Berbery[3]; Javier Cabello[4]; Antonio J. Castro[5]; Beatriz P. Cazorla[4]; Howard Epstein[6]; Néstor Fernández[7]; Esteban G. Jobbagy[8]; Cecilio Oyonarte[4]; Manuel Pacheco[4]; Julio Peñas[9]; María Vallejos[2]
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Essential Biodiversity Variables should capture measurements of the three dimensions reognised for biodiversity: composition, structure and function. Whereas composition and structure (from genes to ecosystems) have been traditionally considered to assess biodiversity, functional components of biodiversity, particularly at the ecosystem level, have been scarcely included. Multiple aspects of ecosystem functioning can be described through remote sensing techniques and integrated to identify Ecosystem Functional Types (EFTs). EFTs can be defined as groups of ecosystems with similar dynamics of matter and energy exchanges between the biota and the physical environment. The dynamics of carbon, radiation, heat and water exchanges have been used to identify EFTs. Most popular EFTs use three descriptors of the seasonal curves of spectral vegetation indices as surrogates of primary production dynamics, one of the essential and most integrative indicators of ecosystem functioning: annual mean (surrogate of primary production), seasonal coefficient of variation (descriptor of seasonality), and date of maximum EVI (indicator of phenology). EFT mapping has being used 1) to characterize the spatial and temporal heterogeneity of ecosystem functioning at the local and regional scales; 2) to describe the biogeographical patterns of functional diversity; 3) to assess the representativeness of protected area networks and to identify priorities for Biodiversity Conservation based in EFTs richness and EFT rarity; 4) to quantify and monitor the level of provision of intermediate support ecosystem services; 5) to improve weather forecast models by introducing the effects of inter-annual changes in ecosystem biophysical properties into land-surface and general circulation atmospheric models. Within CGL2014-61610-EXP and ECOPOTENTIAL projects, we present the conceptual and methodological basis to integrate EFTs in the Essential Biodiversity Variable framework for monitoring functional diversity at the ecosystem level.

## S1.8: Remote sensing-based measures of habitat heterogeneity as an essential biodiversity variable

**Mao-Ning Tuanmu[1];** Walter Jetz
[1] Academia Sinica

Habitat heterogeneity has long been recognized as a key landscape characteristic with strong relevance for biodiversity and its functions. Consistent with theoretical predictions, empirical studies have commonly confirmed a positive heterogeneity-diversity relationship for a variety of taxa. This general relationship suggests that habitat heterogeneity could be a biodiversity-relevant measure of habitat structure and a good state indicator of biodiversity. However, the use of habitat heterogeneity in biodiversity monitoring and conservation planning is held back by a lack of standardized measures at fine grains and over large spatial extents. To address this, we developed 14 heterogeneity metrics based on the textural features of the Enhanced Vegetation Index (EVI) imagery from the Moderate Resolution Imaging Spectroradiometer (MODIS) to characterize global habitat heterogeneity at 1km resolution. The texture-based metrics capture different aspects of habitat heterogeneity and provide fine-grain information in locations deemed homogeneous by traditional land-cover classifications at both continental and global extents. Most of them strongly exceed conventional heterogeneity variables in capturing the spatial variation in bird species richness and functional diversity at a continental scale. By analyzing the temporal trends of the metric values, we also identified global hotspots of habitat homogenization and heterogenization in the last 15 years. Due to the ability of satellite remote sensing to provide both temporally frequent and consistent observations of land surface across large spatial extents, the remote sensing-derived texture metrics provide a strong indicator for biodiversity dynamics associated with habitat heterogeneity and their changes, and have the potential to be an essential biodiversity variable for global biodiversity monitoring.

## S1.9: Terra-i: a pantropical near real time monitoring system for vegetal cover change

**Louis Reymondin;** Oscar Bautista; Jhon Tello Paula Paz
CIAT

The accelerated loss of forest vegetation and its related cover results in a dramatic change in land use that can cause serious damage to biodiversity and ecosystem services of great importance such as water supply, regulation of greenhouse gases and even the prevention of natural disasters. Despite this, in many parts of the world there is not sufficient recent information available to take action on changes occurring in forests in a timely manner.
This presentation will introduce terra-i, a tool developed by the International Centre for tropical Agriculture CIAT, La Haute Ecole d'Ingénierie et de Gestion du Canton de Vaud HEIG-VD and King´s College London and is funded by Global Forest Watch, CGIAR consortium and The Nature Conservancy. It aims to detect vegetation loss at pantropical level in near real-time. The data produced about vegetal cover change has a frequency (16 days) and spatial resolution (250m) which makes it relevant for decisions makers. The focus of this talk will be on the terra-i methodology and its potential uses to inform decision making.
The terra-i tool is based on the premise that natural vegetation follows a predictable pattern of changes in greenness from one date to the next brought about by site-specific characteristics and climatic conditions in the preceding days. We use a Bayesian-probability based neural network to learn how the greenness of a given pixel responds to a unit of rainfall, then apply the model to identify anomalies in the time series which can be attributed to human activities (i.e. non-natural fluctuations in greenness).
Currently, terra-i has produced a map of vegetation loss data available every 16 days between January 2004 and the present date with pantropical coverage. Since this dataset has been made available, it has been updated every two months.
Beside the generation of the data, Terra-i team has used these results in several studies such as identification of areas with high risks of deforestation in the near future, road impact assessment, protected areas effectiveness assessment, trends and rates analysis. Furthermore, the tool has been applied as the official early warning system for land cover and land-use change in Peru. The collaborative framework agreement signed between the International Center of Tropical Agriculture (CIAT) and the Peruvian Ministry of Environment (MINAM) allowed for the implementation of the new early warning system successfully and subsequently the generation of monthly updates. This collaboration has a direct impact on the different working groups such as the General Direction of Land Management (DGOT) and National Protected Areas Service (SERNANP), which use the data for of land cover loss analysis and decision making.
Terra-i data are available free of act charge in the project website www.terra-i.org. Moreover, data are also available in other platforms relevant for general public information. As of December 2014, Terra-i is a core partner in Global Forest Watch (GFW), and contributes its data on forest changes to this worldwide initiative. It enables users to put tree cover loss alerts into context with data on relevant forest cover, communities and biodiversity for an increased understanding of where and why forests are disappearing. Terra-i data can also be seen on the InfoAmazonia

and CartoChaco platforms which were created to raise awareness of the threats to natural habitats in these rich bioregions (Amazon and Gran Chaco Sudamericano) of Latin America.

## S1.10: The packing of trees in forests and its implications for remote sensing

**Franziska Taubert[1];** Markus Wilhelm; Jahn Hans-Jürgen Dobner; Thorsten Wiegand; Andreas Huth
[1] UFZ Leipzig

Forests worldwide are characterized by complex and spatially heterogeneous structures. Tree size distributions are an important outcome of classical forest inventories and have long been used for describing such forest structures and for deriving attributes like forest biomass. There is a high interest to determine key forest attributes from remote sensing. However, detecting tree size distributions has not been reached so far. Here, we present a physical approach for reproducing forest size structures based on stochastic geometry by interpreting forests as tree crown packing systems. The forest packing model is tested for reproducing observed forest structures of two large tropical forest inventories on Barro Colorado Island in Panama and Sinharaja in Sri Lanka (with a total area of 75 ha). The observed tree size distributions can be reproduced successfully as a result of a few simple principles, i.e. site-specific tree allometries, tree mortality, random placement of trees and competition for space. The heterogeneous local structure of forests is also reproduced successfully using our forest packing model. We quantify that most trees grow up to a height of 30 to 50m contributing to the densest height layer of up to 60% filled space. Our approach is an important step towards identifying a minimal set of processes responsible for generating the horizontal and vertical spatial structure of natural forests. Knowledge, especially on the heterogeneous structure of forests derived from our study can potentially enhance the interpretation of remote sensing measurements.

## S1.11: Fragmentation of Tropical Forests: A Forgotten Process in the Global Carbon Cycle?

**Rico Fischer[1];** Katharina Brinck[2]; Jürgen Groeneveld[3]; Sebastian Lehmann[3]; Mateus Dantas de Paula[3]; Sandro Puetz[3]; Joseph O. Sexton[4]; Danxia Song[4]; Andreas Huth[3]
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Tropical forests play an important role in the global carbon cycle. Thereby, deforestation is not only responsible for direct carbon emissions but also alters the forest structure and extends the forest edge area in which trees suffer increased mortality due to altered microclimatic conditions. Combining latest high-resolution satellite maps of forest cover (30m) and biomass with estimates of the edge effect, we found that 19% of the remaining area of tropical forests lies within forest edges. Due to edge effects, fragmentation of tropical forests has caused an additional 10.3 Gt of carbon emissions, which translates into 0.34 Gt C / year during a period of 30 years and representing 31% of the currently estimated annual carbon losses due to tropical deforestation. Fragmentation substantially augments carbon emissions from tropical forests and must be taken into account when analyzing the role of vegetation in the global carbon cycle.

## S1.12: Biomass in the Amazonian rainforest: regionalization of an individual-based forest gap model

**Edna Roedig[1];** Matthias Cuntz[1]; Andreas Huth[2]
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Tropical forests are characterized by their high biodiversity and successional dynamics caused by natural disturbances. These can be captured well on small spatial scales (e.g. with individual-based forest models). By upscaling processes to larger scales, (e.g. the whole Amazon rainforest) important information on forest structures get lost. Here, we introduce a regionalization method for an individual-based forest gap model that does not lose such important structural information. We estimate the biomass of the Amazon rainforest by combining results of the forest model with remote sensing data.
We adapted the individual-based forest gap model FORMIND to several tropical forest sites in central Amazon in order to reproduce forest structure and biomass of different successional stages. We spatially adapted the mortality parameters of early, mid and late successional trees to replicate data from field studies spread over the entire Amazonian rainforest: specific wood density, above-ground biomass and canopy height. This resulted in the regionalized forest model FORMIND-Reg. The results of the regionalized forest model were related to estimates of canopy heights derived from remote sensing data. This enables to analyze biomass of the Amazonian at different successional stages.
The generic forest model could reproduce observed biomass and forest structure for the central Amazon. Biomass in the south-west was overestimated, in the north-east it was underestimated. The regionalized forest model FORMIND-Reg with the adapted mortality parameters could compensate these errors. The correlation of observed canopy heights and simulated successional stages resulted in a biomass map of the Amazon rainforest with a spatial resolution of $1km^2$.

## S1.13: Joining remote sensing and dynamic forest modelling for estimations of intrinsic forest attributes from Lidar or Radar

**Nikolai Knapp;** Rico Fischer Andreas Huth
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Recent developments in remote sensing technology have improved our abilities of forest monitoring remarkably. Accurate 3D scans of forest canopies can be obtained from airborne light detection and ranging (Lidar) and increasingly from synthetic aperture Radar (SAR) satellites (e.g. TanDEM-X, Sentinel-1, BIOMASS). Thus, information on forest heights can be gathered and mapped at large scales and different spatial resolutions. However, the main variable of interest, e.g. in the context of the UN's initiative for reduction of emissions from deforestation and forest

degradation (REDD+), is biomass not height. Further variables which are crucial in understanding the role of forests in the global carbon cycle are productivity, carbon turnover, basal area, stem size distribution, forest age and disturbance regimes. By analyzing inventory data regression models between remote sensing metrics and the intrinsic target variables can be established. For example, canopy height usually forms a strong relationship with above ground biomass. However, the inventory-based calibration requires extensive field campaigns and reaches its limits with variables which are difficult to measure at plot scale, like carbon fluxes.
Here, we propose a new approach where we complement real world ground-truth data with virtual forest inventory data generated by forest simulations. Dynamic forest models help us to understand the links between ecological processes and vegetation structure. Hence, joining the fields of remote sensing and forest modelling will lead to mutual benefits, by increasing structural realism of forest models and facilitating the development and calibration of remote sensing approaches.
For this purpose, we developed a Lidar simulator for the individual-based forest model FORMIND. The target of the first application study was finding good Lidar-based predictors of above ground biomass for a tropical rainforest. Various Lidar metrics have served for forest biomass estimation in the past, with the calibration of the Lidar-to-biomass-relationships traditionally relying on ground-truth data collected manually in field inventory plots. We, instead, used output of FORMIND simulations as virtual inventory data and simulated Lidar measurements resulting in virtual remote sensing data. The tropical rainforest on Barro Colorado Island (BCI), Panama, for which extensive validation data (inventories and Lidar) is available, served as a study site. With the forest model it is fairly easy to generate data that covers the entire range of possible biomass stocks and forest successional states by including typical disturbances in the simulation. This is a big advantage over field inventories which are often restricted. Good biomass predictions were obtained with several different Lidar-metrics, including some that had not been applied on tropical forests before.
Future applications of this modelling approach could go further from static biomass stock to dynamic carbon flux estimation via remote sensing. Furthermore, the methodology can be transferred to SAR observations. This approach allows exploration of the potential of current and future satellite missions (e.g. Tandem-L) for estimating intrinsic forest attributes.

## S1.14: Assessing the impact of management on floristic composition, biodiversity and ecosystem condition: a multi-sensor comparison

**Ruben Van De Kerchove[1];** Hannes Feilhauer[2]; Cedric Marsboom[3]; Jan Staes[3]; Ben Somers[4]
[1] VITO; [2] University of Erlangen-Nürnberg; [3] University of Antwerp; [4] University of Leuven

The extent of species-rich, semi-natural grasslands has declined drastically in Europe over the last 100 years, primarily due to intensive agriculture and afforestation. Consequently, conservation efforts have been directed to maintaining existing areas of these habitats and several projects seeking to restore these semi-natural grasslands (for instance by converting agricultural land) have been installed.
Restoration activities typically imply a combination of different management practices like mowing, grazing and sodding, mainly intended to gradually lower the amount of available nutrients in the soil. For planning, follow-up and monitoring the effect of those activities, maps depicting the spatially-explicit distribution of floristic composition, biodiversity and ecosystem conditions

can be very valuable. However, as it may be difficult to collect this information over wide areas solely from field-based inventories, remote sensing technologies in general, and airborne imaging spectroscopy in particular, might be very useful. A first question which we ask in this study is therefore:
Can we assess the impact of different management regimes (in a grassland system) on the floristic composition, patterns in (beta-) diversity and ecosystem conditions (as expressed in Ellenberg N and R values) from imaging spectroscopy?
Moreover, as in many conservation efforts, budget restrictions often limit the use of imaging spectroscopy, free of charge multispectral sensors like Landsat-8 OLI or Sentinel-2 MSI provide an attractive alternative. Compared to imaging spectroscopy, this multispectral data of course come with a limited spectral information and therefore we also ask the following questions:
Can we also use multispectral sensors for deriving spatially-explicit information on floristic composition, patterns in biodiversity and ecosystem conditions and how do these results compare to maps derived from imaging spectroscopy?
How do spectral and spatial characteristics of the sensor influence the results?
To answer these questions we compared the performance of airborne spectroscopy data (APEX), and multispectral data sets from Sentinel-2 MSI and Landsat-8 OLI, for mapping the floristic composition, beta-diversity and ecosystem condition in "Landschap de Liereman", a Natura 2000 site and part of a LIFE project, situated in the north of Belgium. Based on those remote sensing data sets, maps were generated using a combination of field data, ordination and regression techniques.
Results showed that, although outperformed by APEX, Sentinel-2 provided reasonable accuracies when mapping floristic composition and ecosystem conditions. Compared to Landsat-8, accuracies were about 10% higher. We discuss these observations considering the difference in spectral bands and spatial resolution of the different sensors. Furthermore we also link these results back to the applied management and we discuss the potential of Sentinel-2 for biodiversity research.

## S1.15: Mapping community composition from space

**Pedro J. Leitão;**
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In times of widely acknowledged global biodiversity reduction, the international society has defined targets for halting this reduction, namely the Aichi Biodiversity Targets set by the Convention on Biological Diversity. In order to monitor progress towards these targets, ecologists have proposed essential biodiversity variables (EBV), which should be viable to implement globally. Remote sensing data plays a key role in the global coverage of EBV, either alone or integrated with in situ observations. Community composition constitutes one class of EBV, within which taxonomic diversity is proposed as a suitable candidate variable. Here I propose a standard methodology for mapping community composition from satellite remote sensing data, based on sparse generalized dissimilarity modelling (SGDM). In this two-stage approach, the environmental (remote sensing) data is initially transformed and reduced with a sparse canonical correlation analysis, thus retaining the information relevant to the observed community patterns. On a second stage the transformed data is fit with a generalized dissimilarity model (GDM. While this methodology preserves all the advantages of GDM, it enables the inclusion of high-dimensional data, such as hypertemporal or hyperspectral imagery, as well as data coming from different sources. The method further allows the prediction of community patterns across wide areas, providing a geographically representative in situ data, and is thus suitable for deriving a EBV. Finally, SGDM could be used to estimate temporal changes in community compositions, thus allowing the derivation of biodiversity indicators.

## S1.16: Tree species classification from remote sensing data - thoughts on spectral resolution and scale

**Fabian Ewald Fassnacht[1];** Hooman Latifi; Aniruddha Ghosh; Krzysztof Stereńczak; Aneta Modzelewska; Michael Lefsky; Christoph Straub; Lars Waser
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Tree species information is important for many ecological and economical questions. Amongst them are for examples questions related to the habitat quality of endangered wildlife species or the evaluation of ecosystem services such as the provision of drinking water. For forest managers, tree species information is relevant for adapting current species compositions to climate change, quantifying hazard risks and for efficient planning of harvesting operations.
In boreal and temperate forest ecosystems, the direct mapping of tree species with remote sensing methods has been demonstrated in numerous studies. Nevertheless, a lot of questions remain concerning the operational provision of tree species maps over larger extents.
This work intents to summarize the current state-of-the-art on tree species classification from remote sensing based on a literature review of over 100 papers amended by own experiences from studies conducted with mainly hyperspectral data. General descriptive statistics on the reviewed papers will be presented. Due to the high variety of applied sensor systems, scales and approaches, the more detailed discussion of this work will mainly focus on two methodical aspects: spectral resolution and scale.
Before this background, questions related to (1) the ideal positioning of spectral bands in the electromagnetic spectrum, (2) practical limitations for the operational use of hyperspectral data for tree species mapping; (3) and the search for an optimal pixel size and an appropriate spatial unit for tree species classifications will be discussed.
The study concludes with a summary of existing constraints and the main challenges that have to be resolved to progress towards operational mapping of tree species in boreal and temperate forest ecosystems.

## S1.17: A Hierarchical and Dynamic Seascape Framework for Scaling and Comparing Ocean Biodiversity Observations

**Maria Kavanaugh[1];** Enrique Montes[2]; Frank Muller-Karger[2]; Anni Djurhuus[2]; Jarrod Santora[3]; Francisco Chavez[4]; Monique Messié[4]; Daniel Otis[2]; Scott Doney[1]
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The pelagic ocean is a complex system in which physical, chemical and biological processes interact to shape patterns on multiple spatial and temporal scales and levels of ecological organization. Monitoring and management of marine seascapes must consider a hierarchical and dynamic mosaic, where the boundaries, extent, and location of features change with time. As part of a Marine Biodiversity Observing Network demonstration project, we conducted a multi-scale classification of dynamic coastal seascapes in the northeastern Pacific and Gulf of Mexico using multivariate satellite and modeled data. Synoptic patterns were validated using mooring and ship-based observations that spanned multiple trophic levels and were collected as part of several long-term monitoring programs, including the Monterey Bay and Florida Keys National Marine Sanctuaries. Seascape extent and habitat diversity varied as a function of both seasonal and interannual forcing. We discuss the patterns of in situ observations in the context of seascape dynamics and the effect on rarefaction, spatial patchiness, and tracking and comparing ecosystems through time. A seascape framework presents an effective means to translate local biodiversity measurements to broader spatiotemporal scales, scales relevant for modeling the effects of global change and enabling whole-ecosystem management in the dynamic ocean.

## S1.18: Modelling Afromontane Tree species diversitie with satellite images and topographic data

**Ralph Adewoye[1];** Christian Huettich[2]; Christiane Schmullius[1]; Hazel Chapman[3]
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Afromontane forest ecosystems are highly diverse in both flora and fauna species. Information on species composition and distribution are necessary for adequate conservation strategy. Extensive survey which is often time consuming and labor intensive is required for the assessment of such ecosystem. Remote sensing platform offers a veritable and inexpensive tool for assessing both quantitative and qualitative information on ecosystem biodiversity. This research examines the application of Habitat Heterogeneity Hypothesis in an Afromontane forest ecosystem using features derived from high and medium resolution images combined with topographic data to predict tree species. The relationships between tree species density (α-diversity) and spectral, textural features derived from QuickBird and Landsat-8satellite images and topographic parameters derived from the 30m ASTER DEM using random forest algorithm were assessed with the object based image analysis and random forest algorithm. The predictors of α-diversity were determined based on the variable of importance model from the random forest algorithm. Elevation ($r=0.6$), slope ($r=0.4$) and aspects ($r=0.3$) were the topographic determinant of tree species distribution in the study area. While spectral and textural features significantly contributed to the enhancement of the alpha diversity model in both QuickBird and Landsat images. QuickBird and Landsat ETM-8spectral and textural heterogeneity showed a significant correlation with species richness ($r=0.87$) and ($r=0.53$) respectively. The empirical models developed can be used to predict landscape-level species density in the Afromontane forest of Nigeria and the adjourning Cameron highland.

## S1.19: Mechanisms behind the estimation of photosynthesis traits from leaf reflectance observations

**Benjamin Dechant[1];** Matthias Cuntz[1] Daniel Doktor[1] Michael Vohland[2]
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Many studies have investigated the reflectance-based estimation of leaf chlorophyll, water and dry matter contents of plants. Only few studies focused on photosynthesis traits, however. The maximum potential uptake of carbon dioxide under given environmental conditions is determined mainly by RuBisCO activity, limiting carboxylation, or the speed of photosynthetic electron transport. These two main limitations are represented by the maximum carboxylation capacity, Vcmax (here always understood at a reference temperature of 25° C), and the maximum electron transport rate, Jmax (also understood at a reference temperature of 25° C). These traits were estimated from leaf reflectance before but the mechanisms underlying the estimation remain rather speculative. The aim of this study was therefore to reveal the mechanisms behind reflectance-based estimation of Vcmax and Jmax.
Leaf reflectance, photosynthetic response curves as well as nitrogen content per area, Narea, and leaf mass per area, LMA, were measured on 37 deciduous tree species. Vcmax and Jmax were determined from the response curves. Partial Least Squares (PLS) regression models for the two photosynthesis traits Vcmax and Jmax as well as Narea and LMA were studied using a cross-validation approach. Analyses of linear regression models based on Narea and other leaf traits estimated via PROSPECT inversion, PLS regression coefficients and model residuals were conducted in order to reveal the mechanisms behind the reflectance-based estimation.
We found that Vcmax and Jmax can be estimated from leaf reflectance with good to moderate accuracy for a large number of species and different light conditions. The dominant mechanism behind the estimations was the strong relationship between photosynthesis traits and leaf nitrogen content. This was concluded from very strong relationships between PLS regression coefficients, the model residuals as well as the prediction performance of Narea- based linear regression models compared to PLS regression models. While the PLS regression model for Vcmax was fully based on the correlation to Narea, the PLS regression model for Jmax was not entirely based on it. Analyses of the contributions of different parts of the reflectance spectrum revealed that the information contributing to the Jmax PLS regression model in addition to the main source of information, Narea, was mainly located in the visible part of the spectrum (500-900 nm). Estimated chlorophyll content could be excluded as potential source of this extra information. The PLS regression coefficients of the Jmax model indicated possible contributions from chlorophyll fluorescence and cytochrome f content.
In summary, we found that the main mechanism behind the estimation of Vcmax and Jmax from leaf reflectance observations is the correlation to Narea but that there is additional information related to Jmax mainly in the visible part of the spectrum.

## S1.20: HCAS: A new way to assess the condition of natural habitats for terrestrial biodiversity across whole regions using remote sensing data

**Tom Harwood[1];** Randall Donohue[1]; Kristen Williams[1]; Simon Ferrier[1]; Timothy McVicar[1]; Graeme Newell[2]; Matthew White[2]
[1] CSIRO, Canberra; [2] Victorian Department of Environment and Primary Industries

Consistent and repeatable estimation of habitat condition for biodiversity assessment across large areas (i.e. regional to global) with limited field observations presents a major challenge for remote sensing (RS). RS can describe what a site looks like and how it behaves (using time series), but is unable to distinguish anthropogenic impacts from natural dynamics. Consequently, it is possible to mistake a heavily degraded habitat for a natural habitat, e.g. a logged forest may appear identical to an intact open woodland. This problem is compounded by the existence of multiple natural states in any given environment, and spatial variation in the natural composition and structure of vegetation as a function of variation in environment. Uncertainty in assessing habitat condition from RS is often further exacerbated by sparseness in the spatial coverage of training data. We describe a novel generic, remote sensing-based algorithm called HCAS (Habitat Condition Assessment System), designed to address the above sources of uncertainty and to be highly flexible in its application. It allows for variability in the definition of condition, and in the type and quantity of input data employed. Here we demonstrate the mechanics of the new algorithm in a simple worked example and its practical application in a case study using inferred "natural-only" reference data, reflective remotely sensed data, and associated environmental data, to derive a prototype map of condition for Australia at a 0.01° resolution. We assess the behaviour and shortcomings of the method, and compare the national case study with estimates from two existing national datasets, and field measured condition data observed at 16,967 sites across the State of Victoria. The modelled predictions outperform both of the existing national datasets, explaining 52% of the variability in field observations for well-sampled cells (relative to 8 and 12% for the existing products). The methodology can potentially address some of the key pitfalls of condition modelling, and could be applied in other regions with sufficient coverage of reference data. The approach also has good potential to be extended to work with reference data for which condition is measured on a continuous scale, e.g. from field-based condition assessment initiatives.

## S1.21: Using remote sensing to quantify the ecosystem impact of invasive plant species

**Michael Ewald[1];** Raf Aerts[2]; Hannes Feilhauer[3]; Tarek Hattab[4]; Olivier Honnay[2]; Pieter Kempeneers[5]; Jonathan Lenoir[4]; Duccio Rocchini[6]; Sandra Skowronek[3]; Ben Somers[2]; Ruben Van De Kerchove[5]; Sebastian Schmidtlein[1]
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The impact on ecosystems of invasive species is considered as one of the essential variables needed to monitor biological invasions. For invasive plants impacts have been well documented through field observations and experiments. Observed impacts strongly depend on local biotic and abiotic site conditions making a comparison between individual case studies difficult. Moreover field studies lack to quantify impacts of invasive plant species at coarse spatial scales. Remote sensing can help to fill these gaps.
Using a spatially explicit approach based on information derived from remote sensing, we aim at quantifying impacts of invasive plant species on ecosystem properties (e.g. vegetation structure, biomass, leaf nutrient contents and plant community composition) for different habitat types and at the landscape scale. We use prediction maps of ecosystem properties derived from high resolution airborne hyperspectral and LiDAR data to study differences between invaded and non-invaded areas. Furthermore, we use the remotely sensed data for upscaling ecosystem impacts observed at the plot level. Thereby we focus on two invasive target species in two study

areas, Prunus serotina in a mixed deciduous forest in northern France and Campylopus introflexus in a dune ecosystem in northern Germany. In a first case study we characterized understory light availability and timber volume in forest stands affected by different abundances of Prunus serotina. Invaded stands were characterized by equal or lower timber volume compared to non-invaded ones. Light availability was not reduced by P. serotina shrubs at the stand level. Here, we would like to provide more details about our approach and present further results.

## S1.22: Pattern zonation rules and Very High Resolution satellite imagery for ecosystem extent monitoring

**C. Tarantino;** P. Adamo; V. Tomaselli; G. Veronico; R. Lucas; F. Lovergine; P. Blonda

Ecosystem extent monitoring at Very High Resolution (VHR) (e.g., WorldView2) is at the basis of local/regional decision-making process for conservation purposes. Fragmentation processes often occur at fine scale and accumulate over time with impacts on coarser scale processes. Coastal wetland maps can be updated from VHR by exploiting spatial and temporal ecological expert rules, i.e.vegetation pattern (zonation), plant phenology and geometric properties, from land cover and habitat maps. The vegetation pattern is associated with some major ecological gradients driving the establishment of well-defined vegetation types, spatially arranged according to a specific sequence from the coast towards inland areas. The methodology does not require in-field campaigns, except for validation, but only the elicitation such rules. Their generalization to different sites is discussed. Changes can be automatically detected by comparing map-pairs.

## S1.23: Using the full depth of the Landsat archive to analyze post-war forest cover dynamics in Angola

**Achim Röder[1];** David Frantz[1]; Marion Stellmes[1]; Anne Schneibel; Valter Chissingui[2]; Manfred Finckh[3]; Joachim Hill[1]
[1] Trier University; [2] University of Lubango; [3] University of Hamburg

After more than two decades of civil war, Angola is presently experiencing dramatic socio-economic changes. The richness in natural capital (e.g. oil, uranium, diamonds) has promoted one of fastest-growing economies in Southern Africa, with growth rates of 8% in 2014. As part of the efforts to recuperate from the war, massive investments into infrastructure and building are being made, resulting in the establishment or upgrade of transportation networks, urban building schemes and plans to establish dams for electricity production along the streams. While urbanization is one major process reflecting this, the return of people to their former settlement areas has promoted increasing conversion rates of Miombo woodlands to cropland and the extraction of trees for charcoal production. In addition to this, Angola is expected to become a major producer of food for national and international markets, and large irrigation schemes are beginning to appear along major streams.
To date, a consistent, exhaustive assessment of deforestation dynamics, in particular after the end of the civil war, is still missing, and only isolated case studies exist. To achieve a synoptic

view across the Miombo-Savanna transition zone, we employed the full Landsat archive avail able for Angola. Rigorous radiometric pre-processing has been applied, including automated cloud detection and masking, as well as spatially explicit modeling of the radiative transfer based on date-specific estimations of optical thickness and water vapor concentrations. To account for topography-induced illumination variations, a C-correction was employed.
Multi-seasonal, pixel-based composites were generated based on time-related seasonal breakpoints to derive large-area image datasets covering coincident phenological states of vegetation. Based on these composites, we mapped forest cover distribution and its temporal dynamics using hybrid classification and iterative spectral mixture analysis. Results of this were related to information on population density, hierarchical road network layers and the distribution of land mines, clearly illustrating spatial gradients of these drivers.
To understand the dynamics of shifting cultivation, in particular with respect to fallow dynamics, we used a time series segmentation algorithm (LandTrendr) on the full timeseries of available Landsat data. This allows identifying the year when fields were established and quantifying regrowth or reactivation dynamics afterwards, which is an important input to analyses on carbon stocks, biodiversity or ecosystem services that may be obtained from these areas.
These results are essential to understand how post-war demographic developments continue to affect the distribution and spatial configuration of forests, and subsequently support land management schemes facilitating the protection of Miombo forests and woodlands as major hubs of biodiversity as well as important sinks of carbon in southwestern Africa.

## S1.24: Fish Diversity in the Okavango Delta seasonal floodplains – 12 years of monthly monitoring

**Michael Murray-Hudson;** Kaelo Makati; Ineelo Mosie; Ketlhatlogile Mosepele
University of Botswana

The Okavango Delta in north-west Botswana is a flood-pulsed alluvial fan which lies at the distal end of a drainage basin straddling 3 sovereign states. It is characterized by an annual flood pulse that originates from seasonal rain in the highlands of central Angola and flows though Namibia before entering Botswana's Kalahari Desert. The Delta is a World Heritage Site and supports a rich biodiversity in both flora and fauna.
The seasonal flood pulse peaks at Mohembo in April, traverses the alluvial fan, propagates across a mosaic of channels and islands reaching its maximum extent of inundation in late August or early September, generating a small outflow (~2% of inflow) at its distal distributaries. The system is characterized by very high variability in all environmental drivers. The annual inflow to the Delta varies between a recorded minimum of 5,312 x 106 m3 to a maximum of 16,000 x 106 m3 – a factor of three. The inflow hydrograph can show up to three distinct sub-peaks in a given season driven by the high variability in rainfall; local rainfall over the Delta provides an additional 4000 x 106 m3 on average – but this is subject to possibly higher variability than inflows. The net result of this variability is that no flood is ever the same as any preceding one. Different portions of floodplains are inundated to different degrees and for different durations each year. This variation has a profound influence on the fish populations.
The Okavango fishery is a vitally important resource for many people, and for many other predators in the Delta. In 2004, the Okavango Research Institute established a long-term monitoring programme which is designed to provide information on fish stocks, species composition and

population structure on a monthly and yearly basis. We are trying to understand the relationships between environmental drivers and these parameters in order to understand the resource dynamics better and to provide guidance to managers.
We use multipanel gill nets to collect time series data on catch per unit effort (CPUE), species richness and diversity(H'), biomass and size class distribution, along with water quality parameters(dissolved oxygen, electrical conductivity, turbidity, and pH), upstream discharge (Q) and local water levels.
Here we present some of the results of correlation and regression analyses carried out to find relationships between fish and environmental variation, and to corroborate or improve on previous attempts to model fish population dynamics.

## S1.25: "Satellite Ecology" and "Phenological Eyes Network (PEN)" to bridge climate, ecosystem and biodiversity observations

**Hiroyuki Muraoka**
Gifu University

"Phenology" of plants and vegetation has been the central biodiversity and ecosystem theme in ecology and Earth system science as it is largely variable along geographical gradient and temporal change of climate and also because it links ecological phenomena over the scales from individual plants to continents. Methodology of phenology observations, as the indicator of ecosystem responses to or influence by the climate change, ranges from single-leaf level monitoring of morphology and photosynthetic pigments, to stand-level changes in foliage density by optical measurements, and to landscape and regional measurements of 'greenness' by satellite remote sensing. In addition to these structural and/or apparent changes of the ecosystem and its elements, we need much more attention to observe and assess their ecophysiological status which is strongly influenced by meteorological conditions over temporal scales and hence directly affect ecosystem functions and services such as carbon cycle and primary production. This paper introduces our challenges to link the structural and functional observations at cool-temperate forest ecosystem super-site, "Takayama site", on a mountainous landscape in central Japan (Muraoka et al. 2015, Ecological Research). At this super-site we have established "Satellite Ecology" and "Phenological Eyes Network (PEN)" concepts which aimed to combine in-situ ecosystem research and satellite remote sensing for Climate-Ecosystem-Biodiversity observations by collaborating with observation networks such as JaLTER, JapanFlux and J-BON(Muraoka et al. 2012, in the 1st AP-BON book). Here we particularly focus on morphological and physiological phenology from leaf to canopy and landscape scales, by (1) combining ecophysiological and optical measurements, (2) micrometeorological measurement of $CO_2$ flux between the atmosphere and forest and (3) mechanistic model analysis for quantitative understanding between the scales. Such cross-scale and multi-disciplinary understanding at super-site allows us to use satellite remote sensing data to observe the photosynthesis at regional scale, and further, to find essential ecological processes to be observed at many research sites at global scale. We are willing to discuss on the collaborations to learn from the past data and to share ideas for future observations.

## S1.26: Feld & Vogel - Development of an interactive Application: Satellite-based Habitat Analysis for Indicator Bird Species in the agricultural Landscape - a Tool to meet the EU Biodiversity Targets in 2020

**Helga Küchly;** Annett Frick; Elaine Niemann; Stefan Braumann; Jörg Hoffmann

Covering 210 million hectares of arable and pasture land, almost half of Europe's land is used for agriculture. The intensification and industrialization of agriculture practice has led to a dramatic species and biodiversity loss. The agricultural bird indicator (Bird Census Council 2012) shows a decrease in agricultural bird numbers by 52% since 1980.
The goal of the project is to create an interactive platform for biodiversity to provide everyone involved in the implementation of the new reform with information and assistance for a ecologically worthwhile implementation.
The aim of the project is to develop a standardized automated process that enables an extensive and inexpensive analysis of the status of favorable/unfavorable habitat structure in agricultural areas using remote sensing data. This app also provides support for conservation measures and improvement of habitat structure. The creation of a geoportal with interactive maps will foster the communication between different users and stakeholders, such as government agencies, farmers, and NGOs.
In detail, habitat requirements of selected bird species such as Corn Bunting (Emberiza calandra) will be extracted to satellite remote sensing data. Remote sensing is a promising approach for the development of high quality, but cost-effective and comprehensive methods for landscape information. Multi-temporal satellite data from will be applied for the analysis of the habitat requirements, such as the size and nature of the crop fields, and semi-natural habitats as well as the general land use. With species distribution data from field observation these landscape indicators will be implemented in the species distribution model (MaxEnt). The model predicts the occurrence probability of the species and thus the habitat suitability of the landscape.
These habitat suitability maps will be presented to the user via a browser-based geoportal. The geoportal allows the user to search, query and filter information temporally, spatially, and content based.

## S1.27: The non-stationary link between spectral variation and species density

**Sebastian Schmidtlein;** Fabian Ewald Fassnacht
Karlsruhe Institute of Technology (KIT)

The currently reported "biodiversity metrics to track from space" do not include the number of species per unit area, shortly called species density. This contrasts the importance of this metric which is the most common and critical field-based measure of biodiversity. A discussed candidate indicator of species density is the variation of reflectance observed by optical remote sensing sensors. The "Spectral Variation Hypothesis" (SVH) suggests that variation in reflectance or "spectral variation" of an area is an expression of spatial ecosystem heterogeneity and therefore related to plant species density. Previous tests of the SVH showed that the link between species density and variation of reflectance is non-stationary in scale and time and depends on the landscape setting. Due to data constraints there are no successful attempts so far to disentangle all these effects. The current study addresses this problem. We used comprehensive data on species density over a comparably large geographic extent to look for evidence of generality in the complex relationships. An analysis of regional and temporal patterns of both spectral variation and species density provide an avenue to an understanding of basic principles shaping the links between both variables.

## S1.28: Remotely sensed trends in European spring phenology

**Daniel Doktor[1];** Maximilian Lange[1]; Ralf Seppelt; Franz-Werner Badeck[2]
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Various studies assessed the vegetation response to modified temperature patterns by extracting phenological metrics from satellite observations. While assessments based on ground observations reveal a trend to earlier green-up results of corresponding studies relying on remotely sensed data have been ambiguous. This work integrates and evaluates most commonly used methods to compute green-up dates based on satellite imagery. Effects of those methods on trends of computed green-up dates are subsequently analysed. In contrast to previous studies, NOAA AVHRR daily NDVI observations and 8-day composites of 1 km - rather than 8 km, resolution (1989-2007) of Central and Western Europe were used.
For each method we tested a number of local and global threshold values determining green-up. Local thresholds relate to pixel-specific NDVI maximum and minimum values, i.e. they can vary between years for a single pixel and also between neighbouring pixels. Global thresholds refer to fix NDVI values over all pixels and years. Computed green-up days were evaluated against an extensive phenological ground network and also a phenological model driven by temperature and day length for the area of Germany.
Results reveal substantial differences between applied methods when single years are analysed. For most methods results are closer to ground observations when using local, not global thresholds. Differences between daily and composite products are only minor. For the first time we can show a trend towards an earlier greening up (between 0.5 - 3 days/year) across all implemented methods. The trend magnitude depends mostly on the applied threshold, not the method used. Local thresholds indicate a slight spring advancement. Global thresholds, in contrast, suggest a more pronounced trend towards earlier green-up. Again, differences in trend do not greatly differ when using the daily or composite products. Trends based on local thresholds are in line with observed trends on the ground and modelled trends for the area of Germany.

## S1.29: Satellite-based tree cover as a surrogate for forest bird diversity and abundance in the South American Dry Chaco

**Leandro Macchi[1];** Tobias Kuemmerle[2]; Matthias Baumann[2]; Christian Levers[2]; Francesco Sabatini[2]
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Land use change can have drastic effects on biodiversity by reducing, fragmenting or degrading habitat. Assessing the impact of land-use change on biodiversity is therefore important, yet challenging across large areas or where land-use change, and thus the losses of biodiversity, happens rapidly. Linking local scale biodiversity data and satellite-based information can be a powerful tool to identify proxy variables, and thus contribute to mapping Essential Biodiversity Variables (EBV) across large area. Most studies that describe the spatio-temporal patterns of land-use changes are based on categorical maps of land use/cover, which fails to account for heterogeneity within class, as well as ecotones between classes. Moreover, non-linearity and thresholds, that often characterize the response of biodiversity to land use, may remain hidden. We focus on the South American Dry Chaco, one of the world deforestation and forest degradation hotspots where the rapid expansion and intensification of agriculture for cattle and crop production threatens biodiversity. Intensification along the land use intensity gradient, from natural woodlands to silvipastoral systems to intensified systems and finally soybean agriculture, is characterized by a progressive loss of tree cover, and should thus ideally assessed be described using a continuous tree cover indicator. However, so far the effects of land-use change on biodiversity were explored considering categorical land-use/cover classes only. Here, we combine high-resolution imagery (e.g., QuickBird) and all available medium-resolution satellite imagery from Landsat 8 to model percent tree cover at the ecoregional scale using a Boosted Regression Tree framework. Then, we relate tree cover to different descriptors of bird communities (i.e, richness, community similarity to natural systems). We tested whether satellite-derived tree cover is a good surrogate for different birds diversity metrics; surrogacy value can be measured by evaluating how well a set of sites selected to maximize the representation of tree cover performs in representing bird's richness accumulation. This generates a curve that is compared to an optimal curve equivalent to the best possible surrogacy value, and to a random curve that indicates the representation expected on average in the absence of biological data. Then we describe the relationship of bird communities to land use along the tree cover gradient for each of our indicators to identify non-linearity and potential tipping points in these relationships. Our results showed that tree cover as a surrogate of birds richness performed between the random and the optimal curves. The community similarity showed a tipping point between the 40-60% of tree cover. Also we identified bird species and guilds more sensitive to tree cover changes (e.g carnivores). On a more general level, we show the value of satellite-derived continuous vegetation measures, such as percent tree cover map, as EBVs and thus for broad-scale monitoring of biodiversity.

# Session 2: Species Distribution EBVs

## S2.1: An Essential Biodiversity Variable for addressing species distributions in space and time

**Walter Jetz**
Yale University

The variation of species' distributions in space and time represents one of the most fundamen

tal aspects of biodiversity and its change. Contracting species distributions result in the loss of potentially significant traits and functions from communities and ecosystems, and in extreme cases their extinction globally. Conversely, expanding ranges translate in species invasions and perturbations of communities, and potentially multifold consequences for ecosystem and humans. While an attribute of single species shaped by ongoing ecological and evolutionary processes, in combination the co-occurrence of multiple species determines the composition of biological communities and their associated functions. Geographic distribution information is available for thousands of species worldwide, but can vary strongly in spatiotemporal detail due to vastly uneven raw data, requiring the integration of multiple types of information for EBV capture.
My talk will provide an overview of the key results of the collaborative working group study on the species distribution EBV developed in 2015/16. It will also attempt a preview of key next challenges ahead - data mobilization, modelling, infrastructure - to begin to operationalize the species distribution EBV globally.

## S2.2: Accounting for both spatial and niche aspects in species distribution models

**Yoni Gavish[1];** Charles J. Marsh[1]; William E. Kunin
[1] University of Leeds

Effective conservation and management requires knowledge on the distribution of species at fine spatial resolutions over wide extents, yet such information is rarely available from field sampling. Thus, there have been a growing usage of maps produced by correlative species distribution models (SDMs). SDMs predict the potential distribution of a species based on the characteristic fine-resolution environmental conditions in which the species was found. Such niche-based models usually ignore any spatial aspects that may affect the species distribution pattern (e.g., dispersal limitation). Therefore, incorporating spatial aspects into SDMs may increase their ability to correctly predict the species actual distribution. In fact, downscaling models make use of spatial patterning to predict the level of occupancy at fine scales from coarse-scale distribution patterns, but ignore any environmental data that might inform where such occupancy should be found. As part of the EU-BON project we developed four hybrid models that aim to incorporate both spatial and niche aspects when modelling the distribution of species. The four models differ from one another in the way they modify the SDM's Probability of Occurrence (PoO) map, in their emphasis on the occupancy predicted by downscaling models and in the way they translate the continuous PoO map to a binary Presence/Absence map. In this talk we will shortly introduce the models and compare their performance at several spatial scales.

## S2.3: BioModelos: a web application to integrate expert knowledge and statistical models to estimate the geographic distribution of species in Colombia

**Jorge Velásquez-Tibatá[1];** Daniel López; Cesar Gutiérrez; Iván González; Maria H. Olaya-Rodríguez; María Cecilia Londoño[1]

[1] Instituto Humboldt

Knowledge of species distribution is critical to guide environmental decision making worldwide. Conservation tools such as the identification of optimal sets of protected areas, species reintroduction, management of populations of invasive species, among others, require detailed knowledge of species distributions. Unfortunately, species distributions in tropical regions remains poorly known due to low sampling efforts, limiting informed environmental decision making in the tropics. How can we fill that gap? Two approaches have been broadly used to characterize species distributions worldwide, namely species distribution models (sdms) and expert maps, whose performance depends mainly on the quantity and quality of available distribution data. On the one hand, sdms are objective and reproducible, but demand sufficient good quality occurrence data and dispersal limitations must be accounted for to accurately characterize species distributions. On the other hand, expert maps might reflect well the general limits of a species distribution and they are useful when there is not enough data to develop an sdm but are largely subjective and non-repeatable.
Taking into account the crucial role that species distributions information has to manage and use the territory, we have developed BioModelos (http://biomodelos.humboldt.org.co/), a web application that integrates both expert opinion and sdms to map species distributions, to balance the shortcomings of both approaches at different sample sizes. BioModelos is an open and participatory tool in which experts on various taxonomic groups can (1) verify the accuracy of point distribution data (taxonomically and geographically); (2) choose amongst different sdms and thresholds the one that in their opinion best reflects a species distribution, publish their own species distribution models or create new expert maps; (3) edit sdms for omission and commission errors and (4) provide ecologically relevant information (e.g. landcover) to map species distributions at regional and subregional scales. BioModelos currently provides species distribution models for nealy 5800 species that inhabit Colombia and has constituted a network of over 100 experts in all major taxonomic groups that collaboratively improve and fill the gaps in the knowledge of species distribution in a megadiverse country.

## S2.4: Occurrence as central and essential for monitoring range expansion

**Melodie McGeoch;** Guillaume Latombe
Monash University

Spatially explicit presence-absence (occurrence) records are the basic unit for quantifying the geography and movements of species and monitoring range expansion. Climate change and biological invasions have increased the likelihood of the establishment, growth, spread and survival of some species. With the strongly motivated call for balanced consideration of the ecology and conservation of common and rare species, species undergoing range expansion are of particular interest. The concept of Essential Biodiversity Variables has also focussed attention on the value of occurrence observations for assessing the status of species whether they are rare or common, contracting or expanding. Species occurrences, for alien and native species, contribute directly to the species distribution EBV. For alien and invasive species, the existence of harmonized occurrence data across countries from multiple taxonomic groups would significantly facilitate quantification of the size, extent and nature of biological invasions globally.

The occurrence of alien species at any particular scale of interest provides the basis for quantifying several derived variables and indicators of invasion. Tracking the spread of alien species and evaluating the success of policies and management interventions is achieved by repeated measurement of occurrence records of alien species, which enables the assessment of their geographic distribution. Changes in the distribution of common and range expanding species deserve further attention, not only to better understand their dynamics, but also as the basis for monitoring range expansions and their consequences.

## S2.5: From counts to indicators - progress in butterfly monitoring

**Eugenie Regan[1];** Chris van Swaay[2]
[1] The Biodiversity Consultancy; 2 De Vlinderstichting

Monitoring butterflies is one of the oldest examples of citizen science and there are now many butterfly monitoring schemes throughout Europe, North America, and other parts of the world. The results of such schemes have proven invaluable in providing robust data on changes in species distributions and population abundance (essential biodiversity variables) in nature reserves, local areas, countries and even whole regions, such as Europe.
Currently butterfly monitoring and the underlying methodologies is well established in temperate regions such as Europe and North America. However, these methodologies are not always suitable for tropical regions, making it more difficult to monitor essential biodiversity variables in these regions. With support from GEO BON, a small group of international butterfly experts came together in 2014 and 2015 to develop generic field protocols for monitoring butterfly population abundances and species distributions that can be applied in any part of the world. Together they produced 'Guidelines for Standardised Global Butterfly Monitoring' published by GEO BON. The guidelines explain how to set up butterfly monitoring that can provide consistent and comparable results between sites and between years, consistent with international standards. They will enable the growth of butterfly monitoring around the world and make possible the creation of a Global Butterfly Index.

## S2.6: From species distribution models to community prediction: perspectives for EBVs

**Manuela D'Amen;** Amen Antoine Guisan
University of Lausanne

Species distribution EBV are critical for informing multiple environmental indicators and conservation actions. In this context species distribution model (SDM) play a fundamental role to integrate and homogenize the presence, absence, or abundance data collected for the different species and extrapolate from specific locations to larger scales. Individual species models can inform not only species distribution variables but also different community properties EBVs (i.e. species richness and taxonomic composition), which are often used for prioritizing conservation action and in turn represent the biological foundation of ecosystem services. The classical approach to estimate community properties from individual models is to stack species predictions.

This method is straightforward and easy to apply, but it implicitly assumes that assemblages are the simple sum of individual responses to the environment. This theoretical simplification may produce biases in the reconstruction of communities. Analyses on richness and composition predictions produced by stacking individual models from established SDM techniques (e.g. Generalized Linear Models, Maximum Entropy models, Boosted regression trees, etc.) give discordant evaluation. The stacking of binary SDMs may not predict the actual number of species in the community, and it has been shown to exceed in some cases (often with plants) the actual number of species found in each unit. Such bias has been explained either with a technical biases in thresholding and then summing individual predictions or with a biological reason, i.e. SDMs using only environmental variables would predict more species occurring in each site because they do not consider additional community drivers, such as the limited environmental carrying capacity and the exclusion of some species by biotic interactions. Other studies focusing on insects and birds report instead a good predictive capacity. In these last cases, the authors hypothesized that the inclusion of resource-related variables in the SDMs allowed a greater approximation of the species realized niche, this already limiting the overprediction bias when stacking the predictions at the community level. Further tests are needed to explore to which extent the bias on community estimations depends on different taxonomic groups, areas, and scales, and if different techniques (e.g. hierarchical Bayesian species distribution models) or groups of predictors (i.e. resource-related variables) can improve the community-level predictions. In addition, new community-level approaches have been proposed to correct potential biases from stacking single species models, by integrating in a unique modelling framework multiple drivers of community assembly.

## S2.7: Prototyping the Essential Biodiversity Variables for species populations – an analysis of trends in relative abundance for all European butterflies using big data from GBIF

**Yuliya Fetyukova;** Hannu Saarenmaa
University of Eastern Finland

In a joint GEO BON / EU BON workshop in Leipzig in 2014, the Essential Biodiversity Variable (EBV) for species populations was tentatively defined as the relative abundance of a taxon in a given place and time, measured repeatedly, using a consistent methodology.
The traditional approach to derive trends in abundance is based on repeated species counts in the field, following a detailed scheme, and then computing the trends using statistical tools such as TRIM. This works well, but is expensive and requires detailed coordination, which is not feasible in large scale. We introduce another approach using big data: By combining data from thousands of volunteer and opportunistically gathered sources, the trend of a species can be computed as the proportion of its occurrences among all the occurrences in a large data source, in a major taxonomic group, such as family or order.
This was prototyped for all European butterflies using data from GBIF. Five million raw records were downloaded, and consolidated to three million situated in Europe and without duplicates. Because of the large number of species and records, an automated data cleaning workflow, written in R was created. A major step in data cleaning was synonym resolution. 624 different name strings and 441 numeric codes were merged through synonym resolution to unique 347 butterfly

species. The condensed data, which was put into a data cube for online analytical processing, included only species name, year, latitude, longitude, country, and basis of record (specimen or observation).
The temporal distribution in the data is strongly skewed. Between 1960 and 1990, there were less than 20,000 records annually, which stem mostly of specimens in collections. From 1990 onwards, online citizen portals become available, and in the peak years there were up to 200,000 observations recorded annually. Only about 5% of all data is from digitized specimens, and the rest are observations – mostly casual sightings or results of monitoring activities. Specimens may be preserved also from these records, but there is no indication of this in the available data.
The spatial distribution of the data is equally biased. From ten countries (starting from largest: UK, SE, CH, FI, DK, DE, PL, IE, FR, NO) more than 50,000 records are available. We could therefore make comparisons between the butterfly trends in these countries. We also grouped countries in three major areas (Nordic, British Isles, central continental Europe). We were unable to use the scattered data from southern and eastern Europe for any comparisons.
We could detect a statistically significant slope (increase or decrease) in 39% of the Nordic species, 53% of the species on British Isles, and 49% on the species on the continent. Out of these 40%, 28%, and 21%, respectively, were positive (increasing) and the rest were negative. This corresponds to findings in other studies about butterfly decline in Europe.
The trends in neighbouring countries were correlated, which was analysed statistically. In these analyses, population fluctuations such as disappearing and recovering of Aglais urticae in northern Scandinavia after the climate events in 1987, 1998, and 2014 is clearly visible in the trends computed for the different countries. Likewise, the mass migration of Nymphalis xanthomelas from the Black Sea to the north of Europe in 2013 is clearly reflected in the data.
Despite of the obvious and huge biases in opportunistic data, we conclude that deriving abundance from occurrence yields real results, when using openly shared, and semantically aggregated data from thousands of disparate sources. This gives new possibilities for making EBV processing operational in near real time. Still, further research is necessary to uncover all the caveats in this process.
Filling the temporal gaps through digitisation of old data and filling the spatial gaps through data sharing from more countries is very much needed.

## S2.8: Biodiversity records in spanish historical sources and the options for a bon of the past

**Miguel Clavero**
Estación Biológica de Doñana - CSIC

Past processes and events influence contemporaneous ecological patterns, including current human impacts on landscapes and organisms. Historical information is thus critical for assessing long-term changes of the distribution of biodiversity in response to global change processes. In spite of this, the management of natural systems is most often based on knowledge built upon short-term data collections, which very rarely exceed one decade. A diverse array of historical sources containing information on natural resources is available across different regions of the world and can be used to compile biodiversity records, expanding the time-window of our approaches to describe the dynamics of biodiversity patterns.

The Relaciones de Felipe II (late 16th century) and the Madoz Dictionary (mid-19th century) are two Spanish historical written sources originally thought to provide geographical descriptions that containing information on natural resources. Both sources contain several thousands of records of wild plant and animals, which have already served to address relevant ecological questions related to habitat loss, climate change, biological invasions or the definition of conservation baselines. While being important documentary sources, the Relaciones and the Madoz are not unique, neither in Spain nor in other areas. There is in fact a yet unexplored potential to develop a transnational biodiversity observation network of the past, as exemplified by the spatially-precise databases of biodiversity records generated from Spanish sources. This BON should be feed by georeferenced historical records collected through a necessarily collective and participatory approach.

## S2.9: An Impact of Climate on Tree Species Diversity in Tropical Reserve Forest using Geospatial Domain

**Pavan Kumar**
Kumaun University

Forest is a tool mentioned for ecological balance and environmental set up. It performs social, ecological and economical functions to the living organisms such as it preserves the natural resources for the sustainable use, lesser soil erosin, preserves the animal habitat etc. Forest degradation in the tropics is of significant concern because of the substantial losses of biomass and habitat fragmentation. Geographic Information System (GIS) has been proven in many studies and experiences to aid in the decision-making process based on Multi-Criteria techniques. The advancement in remote sensing coupled to Geographic information system expedites the adverse changes in forest vegetation and the assessment of impact of various factors such as climatic change or human activities on forests.This study aims to evaluate an assessment of tree species diversity of the Sariska Tiger Reserve using GIS and Multi criteria techniques. Vegetation indices among other methods have been reliable in monitoring vegetation change. One of the most widely used indices for vegetation monitoring is the Normalized Difference Vegetation Index because vegetation differential absorbs visible incident solar radiant and reflected much of the infrared. Data on vegetation biophysical characteristics can be derived from visible and NIR and mid-infrared portions of the electromagnetic spectrum. Four forest types, namely Anogeissus pendula, Boswellia serrata, mixed Anogeissus butea and mixed Acacia zizyphus are mainly dominant in the forest cover of Alwar district. Satellite data of LISS III (2012) give precise information of vegetation through reflectance value.
Keywords: NDVI; Mapping; Inventory; Site Suitability

## S2.10: Comparing Generalized Linear Models and random forest to model vascular plant species richness using LiDAR data in a natural forest in central Chile

**Javier Lopatin;** Klara Dolos; Jaime Hernández; Mauricio Galleguillos; Fabian Ewald Fassnacht[1]

[1] KIT - Karlsruhe Institute of Technology

Biodiversity is an essential element of the Earth system, related to many important ecosystem services. Cost-efficient and precise monitoring systems are needed to support the conservation of biodiversity in a quickly changing world. Here, we tested the suitability of airborne discrete-return LiDAR data for the mapping of vascular plant species richness of second growth native forest ecosystem in central Chile. We modelled the vascular plant richness of four layers (total, tree, shrub and herb richness) using twelve LiDAR-derived variables. As species richness values are typically non-normally distributed count data, the corresponding asymmetry and heteroscedasticity in the error distribution has to be considered. We therefore compared the suitability of random forest (RF) and a Generalized Linear Model (GLM) with a negative binomial error distribution. In both cases, a feature selection to identify the most relevant LiDAR predictors was applied as a first step. In both model types, the three most important predictors for all four layers were altitude above sea level, standard deviation of slope and mean canopy height. This agreed with our preconception of LiDAR's suitability for estimating species richness which we hypothesized to be its capacity to capture three types of information: micro-topographical, macro-topographical and canopy structural. Generalized Linear Models showed higher performances (r2: 0.66, 0.50, 0.52, 0.50; nRMSE: 16.29%, 19.08%, 17.89%, 21.31% for total, tree, shrub and herb richness respectively) than RF (r2: 0.55, 0.33, 0.45, 0.46; nRMSE: 18.30%, 21.90%, 18.95%, 21.00% for total, tree, shrub and herb richness, respectively). In addition, the best GLM models were more parsimonious (three predictors) and less biased than the best RF models (twelve predictors). We explain this with the mentioned non-symmetric error distribution of the species richness values, which RF could not capture properly.
From an ecological perspective, the predicted diversity maps agreed well with the known vegetation composition of the area. High species numbers were found at low elevations and along riversides. In these areas, overlapping distributions of thermopile sclerophyllos species, water demanding Valdivian evergreen species and species growing in Nothofagus obliqua forests occur. Our three main conclusions were: 1) appropriate model selection is important when working with biodiversity count data; 2) RF has troubles when applied to data with non-symmetric error distributions; and 3) structural and topographic information derived from LiDAR data is useful for predicting local plant species richness.

## S2.11: The potential of new technologies for biodiversity monitoring at species level

**Wolfgang Wägele**
Leibniz-Institute for Animal Biodiversity - Museum Koenig

Taxonomic determination of species found in habitats or in bulk samples is time-consuming and requires an expertise that often is not available. Therefore, taxonomy usually is an impediment to biodiversity monitoring at species level. This obstacle can be overcome with emerging new technologies. They require the construction of expert systems that perpetuate taxonomic knowledge in databases . Sensors that detect species comparing signals from the environment with reference information in databases can be built based on bioacoustics, automated image recog nition, automated detection of volatile organic compounds, complemented with partly automatized sampling and DNA-barcode analyses. The goal is to implement a network of multisensor stations that function like meteorological stations.

## S2.12: DaEuMon - a database on biodiversity monitoring in Europe: updates

**Klaus Henle**
Helmholtz-Zentrum für Umweltforschung - UFZ

Monitoring data has received centre stage, due to the instalment of the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES), GEO BON and other national and international initiatives. However, while knowledge about monitoring efforts is important, few overviews on monitoring activities exist and existing overviews still miss a large variety of available programs and biodiversity data.
As a response to the fragmented nature of biodiversity monitoring and the difficulty to know what activities exist in Europe, their coverages and gaps, strengths and weaknesses, the EuMon project (2004-2008; biomat.ckff.si) created Europe's most comprehensive metadata catalogue of biodiversity monitoring activities. The metadata cover, among others, information about the higher taxa and species as well as habitats monitored, spatial and temporal coverage, study design, data analyses, costs, number of people involved, and funding. A second database covers information about monitroing organizations, including among others, information on data sharing, recruiting volunteers and challenges and solution to retaining monitoring activities.
The EU BON project (2012-2017) (www.eubon.eu) is now building a new portal where this information is highlighted. Therefore, the original EuMon monitoring meta database is now being expanded with new information on data availability, access, and also by new information from the marine realm and remote sensing.
The presentation provides an overview of the database and shows examples, how data can be extracted and summarized. It provides an update on recent efforts to expand the number of monitoring schemes covered by the database and promotes further entries to the database.

## S2.13: The Wildlife Picture Index: an essential biodiversity variable to monitor vertebrates through camera traps

**Jorge Ahumada[1];** Lydia Beaudrot; Patrick Jansen; Tim O'Brien
[1] Conservation International

There is a need in the scientific and conservation world to understand better how and why wildlife populations are changing, specially in ecosystems that are threatened and where there are large knowledge gaps (e.g. tropical forests). Camera traps and other automated sensors are helping us collect large amounts of information on wildlife, but indicators of change derived from these data remained poorly understood. The Wildlife Picture Index (WPI) is a promising and flexible essential biodiversity variable that measures changes in biodiversity using camera trap data, but relatively little is known on its sensitivity to detect change. We examine the temporal sensitivity and statistical power of the Wildlife Picture Index (WPI), under different scenarios of sampling effort and temporal dynamics of the underlying species. Using a dynamic occupancy model we simulate changes in 1, 3, 5, 10, and 15% in occupancy of 25 species and under different sampling effort (30,60, 90, 120 points leaving each point for 10, 15, 30, 45 and 60 days in the field) and different mixtures of species (all declining, half declining, a third declining, a fifth declining). Under each of these scenarios we calculate the WPI and test whether it recovers the underlying dynamics of the community. We apply this knowledge to the real analysis of multi-year and multi-species data coming from the TEAM network. We show that the index is sensitive to small changes in occupancy of the underlying species when most species are declining in the community.

## Session 3: National BONs and tools for BON development

### S3.1: A Process and Approach to Developing a User-Driven Biodiversity Observation Network

**Mike Gill**
GEO BON

Developing a national or regional Biodiversity Observation Network (BON) that is sustainable, efficient, powerful and well connected to policy needs requires a systematic, open and inclusive process for successful development and implementation . As well, it is important that a national BON does not develop and operate in isolation, but rather draws from and contributes to broader regional and global biodiversity observation efforts while, at the same time, allowing flexibility and customization to respond to national and sub-national needs. In this regard, the Group on Earth Observations – Biodiversity Observation Network (GEO BON; www.geobon.org) is focused on working with national and regional organizations to help facilitate effective and efficient biodiversity observation networks that, first and foremost, respond to and serve user needs at the national and sub-national level (e.g. policy and decision-makers). While also contributing to the development of a global, interoperable network for biodiversity observations that improves our overall ability to detect, track and understand global and regional biodiversity trends.
The development of a successful and sustainable biodiversity observation network requires a careful and sequenced approach that ensures inclusivity and close connections to user needs. Drawing upon lessons learned from the establishment of national and regional BON's in different parts of the globe, this presentation will outline the nine step process for building a biodiversity observation network that GEO BON is employing.

### S3.2: Bon in a Box Latin America, challenges and opportunities

**Maria Londono[1]**; Mike Gill[2]
[1] Humboldt Institute; 2 GEO BON

BON in a Box aims to serve as a technology transfer mechanism that allows countries access to the most advanced and effective monitoring protocols, tools and software thereby, lowering the threshold for a country to set up, enhance or harmonize a national biodiversity observing system. The regional pilot of BON in a Box in Latin America, led by the Humboldt Institute and developed in 2015, resulted in a web-based Beta version. This version contains a number of state-of-the art tools for data collection, management, analysis and reporting that can be easily discovered through a smart search mechanism that queries specific tool attributes. It also includes a web-based platform for entering tools and related communication material. Beta development was informed through both a survey sent out to over 1000 recipients in central and South America and a regional workshop were the greatest capacity building needs around supporting biodiversity observations and related decision-making were identified. With the launch of the beta version and in the context of national and international needs, it became evident that the full version will need to be aligned as much as possible with related capacity building efforts underway and with a focus on supporting the needs of the Parties to the Convention on Biological Diversity and Intergovernmental Platform on Biodiversity and Ecosystem Services. As such, BON in a Box: Latin America will be used to assist in the development of the Colombian BON thereby, allowing for the testing and adjusting of the toolkit to maximize its effectiveness. In order for the full implementation to be successful, a series of challenges need to be addressed by GEO BON in the conceptualization and collaborative building of this tool box. For example, the structure for classifying and characterizing tools needs to be adaptable to different themes, scales or regions while also ensuring consistent and centralized tool data management. As well, an efficient means for enabling GEO BON's Working Groups and experts to actively support and improve the toolkit on an ongoing basis will need to identified.. Furthermore, a communication strategy and business plan needs to be defined and implemented in order to allow for the fostering of regionally customizable versions of the toolkit and continually updated online toolkit. To date, the Latin American lead for BON in a Box has inspired the planned development of specific themes for the toolkit including a Marine version and development of customized toolkits for African biodiversity observations.

## S3.3: How EBVs can help national biodiversity and ecosystem service monitoring?

**Petteri Vihervaara;** Ari-Pekka Auvinen; Laura Mononen; Saku Anttila; Martin Forsius; Jani Heino; Janne Heliölä; Meri Koskelainen; Mikko Kuussaari; Olli Ojala; Seppo Tuominen; Markus Törmä; Markku Viitasalo; Raimo Virkkala
Finnish Environment Institute (SYKE)

Essential Biodiversity Variables (EBV) are suggested to harmonize biodiversity monitoring worldwide. Current biodiversity monitoring on national level comes in a multitude of variations all, however, aiming to respond the challenge of halting biodiversity loss and reporting to international agreements such as the Convention on Biological Diversity. Finland has long been one of the most advanced countries in assessing the status of endangered species and recently also of habitats. So far these assessments of the state of biodiversity and ecosystems have been largely based on expert knowledge. For certain groups of species monitoring programmes are supported by the state, while most are conducted on voluntary basis. Comprehensive reporting on EU directives has been prepared already for nearly 20 years by experts and officers.

A few biodiversity data are objectively measured, and even less are extensively spatially covered and studied on the basis of true occurrence. Today the traditional work-intensive way of gathering and preparing data confronts serious challenges in particular due to cuts in state budgets. At the same time, rapidly emerging new opportunities such as remote sensing (from drones to airborne laser scanning and new satellites such as VHR as well as the overall Copernicus programme) and DNA sampling techniques are opening a whole new world of opportunities for monitoring the state of biodiversity and ecosystems. Further, the opportunities also cover the wider concept of ecosystem services. In this presentation we i) describe the current Clearing House Mechanism of Finland (www.biodiversity.fi) including national biodiversity and ecosystem service indicator frameworks, and ii) evaluate how the recent development of EBVs could assist in filling in remaining data gaps of indicators and help in building a harmonized monitoring system of the state of Finnish nature.

## S3.4: German Federation for Biological Data (GFBio)

**Michael Diepenbroek**
University Bremen

The German Federation for Biological Data (GFBio) aims to set up a sustainable, service oriented, national data infrastructure facilitating data sharing and stimulating data intensive science in the fields of biological and environmental research. GFBio follows a holistic approach including technical, organizational, cultural, and policy aspects. The development of the infrastructure is essentially based on the collective experience and expertise of leading researchers from multiple disciplines as well as on a network of complementary and professional data facilities in the biological and environmental sciences communities, including PANGAEA, major German natural history collection data repositories, and selected facilities from the molecular biology research community. GFBio is projected for three phases setting out the way from development to management of services. The preparatory phase focusses on conceptualizing and prototyping GFBio components such as the archive backbone and the service platform. The current phase II concentrates on implementation and the last phase on consolidation of the infrastructure. Phase II tasks are focused on bringing GFBio into its full-featured operational state. In particular, (1) the interoperability and data organization of the archive backbone is adapted to fit GFBio requirements. This includes support for data harmonization through integration of relevant ontologies. (2) Available data management knowledge and resources are harmonized and compiled into a coordinated helpdesk. A key area of focus here is to improve the context with science by embedding data management into nationally funded biodiversity projects and to establish GFBio as the national authority for management of environmentally related biological data. Further (3) GFBio will provide a fully operational data portal allowing discovery and access to affiliated data facilities and selected international data providers. (4) A Virtual Research Environment (VRE) is set up integrating heterogeneous data from GFBio affiliated data providers and supplying basic visualization and analysis tools. The VRE will enable users to efficiently aggregate, transform, and filter complex and large data volumes. The data portal will allow a seamless transition from data discovery to the VRE. (5) GFBio services will be embedded into the international community by improving and extending interoperability, fostering usage of standards, and aligning GFBio to essential data management policies. Sustainability and effectiveness of GFBio is ensured by developing a business plan and setting up an association for supplied services.

## S3.5: Humboldt-Core – toward a standardized capture of biological inventories for biodiversity monitoring, modeling and assessment

**Robert Guralnick**

Taxonomic inventories serve as a critical means to assess local to regional biodiversity. However, reporting standards that would allow these inventories to be re-used, compared to one another, and further integrated with other sources of biodiversity data are lacking, impeding their broadest utility in biodiversity science. Here we provide a conceptual framework for different inventory processes and outputs, and a draft standard for capturing inventory metadata, dubbed Humboldt Core, based on the outputs of a community input process and significant effort to refine initial outputs based on extensive testing of the standard against published inventory descriptions. Our framework provides a typology of inventories and clarifies different types of inventories and inventory processes, providing a needed distinction between more temporally and spatially restricted single source inventories, and more broad-scale summary inventories. This framework is critical for developing the fine-grain capture of more detailed information about how inventories were performed, which forms the Humboldt Core, including capture of geospatial, temporal, taxonomic and habitat scope along with methodological descriptors related to assessment of sampling effort and inventory completeness. We describe how Humboldt Core has been successfully applied to a major effort to ingest and provision inventory data and metadata into the Map of Life
project. A key output of the metadata ingest is the ability to assess quality and completeness drawn from hundreds of published inventories, and from that effort we show that only a minority of summary inventories are assessed as being mostly complete. We close by
discussing next steps in further development of this new standard and integrative approach for biodiversity science.

## S3.6: PlutoF – online data management platform for the Biodiversity Observation Networks

**Urmas Kõljalg[1];** Kessy Abarenkov; Allan Zirk; Veljo Runnel
[1] University of Tartu

PlutoF (https://plutof.ut.ee) is an online interdisciplinary data management platform covering full data life cycle - from creating to the re-using of the data. It allows to create and manage databases on biodiversity and associated disciplines. Researchers, Citizen Scientists and stakeholders can easily team up by forming workgroups with mission to create specific databases. Biodiversity Observation Networks (BON) can develop their own databases including taxon occurrences, taxon classifications, DNA sequences, traits, locality, habitat, etc. across different Kingdoms. These data can be easily shared online with other BONs or published as Open Data. BON can have a single project with several databases or every database can have its own project. Project descriptions include rich metadata and unlimited number of sites/observation areas. User access and rights to edit data is managed through the Access Rights module. Processing data, viz. entering, checking, validating, cleaning, annotating, etc., can be done in fully online mode. Every user can search over all public datasets, including his private data, at the

same time using a single search module. The same applies to the analyzing and exporting data. BON may also generate its own data portal through the API connection.
There are specific modules on the workbench to help users with importing their data from CSV files, exporting in various formats (e.g. CSV, JSON, PDF for specimen labels, FASTA for DNA sequences), and displaying data on the maps.
PlutoF supports open data and data publishing in various ways – support for Digital Object Identifiers (DOI) is provided by direct link to DataCite (https://www.datacite.org/), publishing to GBIF can be set up on demand, and publishing in Pensoft journals (http://www.pensoft.net/) is made easy through import options in ARPHA Writing Tool (http://arpha.pensoft.net/) and automated creation of EML formatted metadata for datasets.
There are currently over 2,000 registered users from 75 countries (https://plutof.ut.ee/#/statistics).

## S3.7: GBIF - a global infrastructure for species population data

**Donald Hobern**
Global Biodiversity Information Facility

The Global Biodiversity Information Facility (GBIF, http://www.gbif.org/) is an international, intergovernmental initiative to mobilise and organise open data on the recorded occurrence of species in time and space, including data from natural history collections, field research, environmental genomics, citizen science and literature. Since its establishment in 2002, GBIF has provided leadership in delivering tools, standards and best practices for mobilising biodiversity data for free and open use by the research community and to support policy applications. As of March 2016, this resource brings together more than 650 million data records from data-holding institutions and organisations around the world.
GBIF has recently expanded its data publishing software and data indexing systems to incorporate additional data elements from projects which follow consistent standardised methodologies to sample or survey species within a taxonomic group. Examples of such projects include vegetation plot surveys, bird atlases, butterfly or reef transects, malaise sampling, microbial ecogenomics, etc. The Sample Event Extension to the Darwin Core record format (used by GBIF and many other biodiversity data initiatives) includes elements to model a set of species records arising from a single sampling event and to connect each such sampling event with any others carried out using the same methodology. Wherever possible, relative abundance of each species within the sample can also be shared. Further work will be required to catalogue methodologies referenced in these data and to model relevant level of effort, species detectability, etc., but this small enhancement to GBIF's existing processes allows users to discover and access those datasets which offer the greatest opportunities for statistical comparison.
Even in the absence of data collected according to standardised methodologies, the GBIF network increasingly brings together sufficient data for species distributions to be modeled at useful scales and for temporal trends to be recognised, thus contributing to EBVs and other indicators required by policy makers. There is a clear correlation between data availability and the grain at which both spatial and temporal variation can be detected.
The GBIF infrastructure exists as a globally open platform for ecologists and other biologists to collaborate in building the largest and best possible repository of evidence for species distributions and populations and for community composition. We encourage researchers and policy

makers everywhere to mobilise and integrate all available streams of species observations and biodiversity sample data.

## S3.8: Biodiversity monitoring in China from CForBio to Sino BON

**Keping Ma**
Institute of Botany, Chinese Academy of Sciences

Forest is maintaining 80% of the carbon stocks of vegetation on earth. So, forest plays a critical role in mitigating climate change. In this sense, forest dynamics plot approach can be a useful platform for carbon research. We began to set up the Chinese Forest Biodiversity Monitoring Network (CForBio) in 2004. Before that, we have established a number of similar permanent plots for the same purpose, but much smaller in area. Up to now, we have set up 13 plots with the area more than 9 hectares. The plots are distributed in different climatic zones. In cold temperate coniferous forest region (Great Xingan Mt), there is a 25-hectare plot; In temperate coniferous and broadleaved mixed forest region (Changbai Mt., Fenglin and Liangshui), there are 1 30-hectare plot, 1 25-hectare plot and 2 9-hectare plots; In warm temperate broadleaved forest region (Dongling Mt. and Baotianman), there are 1 25-hectare plot, 1 20-hectare plot; In subtropical evergreen broadleaved forest, there are 1 25-hectare plot (Badagong Mt), 1 24-hectare plot (Gutian Mt.) and 2 20-hectare plot (Tiantong and Dinghu Mt.); In seasonal tropical rain forest region, 1 20-hectare plot (Xishuangbanna) and 1 15-hectare plot (Lenggang). The key features of the forest dynamics plot approach are mapping and tagging. All of the stems with DBH more than 1 cm in the plots were mapped and are re-censused in every 5 years. The major objectives of the network are 1) to know the dynamics of major types of ecosystems in China; 2) to understand the mechanisms of species coexistence and associated impact factors such as logging, climate change. From 2013, we began to expand the current forest biodiversity monitoring network for covering major taxa of species in most of the dominant ecosystems in mainland of China. The Chinese Academy of Sciences decided to invest 30 million USD to expand the network from CForBio to Sino BON. Sino BON consists of 1 synthesis center, 3 thematic sub-centers, i.e zoological sub-center, botanical sub-center and microbiological sub-center, and 10 branch networks under the 3 sub-centers.

## S3.9: The Colombian Biodiversity Observation Network: a pilot for establishing National BON's to Serve the Strategic Plan for Biodiversity and the Intergovernmental Panel for Biodiversity and Ecosystem Services

**Maria Londono[1];** Mike Gill[2]
[1] Humboldt Institute; 2 GEO BON

Although Colombia has a National Environmental System since 1991 there is still little incidence of biodiversity data informing decision making. National and subnational environmental assessments are mainly qualitative and there are difficulties in accessing robust quantitative data to track biodiversity change. Colombia has indeed many monitoring projects and tools, but they are disparate, with little harmonized approaches to observations and relevant questions for decision making are not addressed. In 2015, Colombia's Humboldt Institute developed a conceptual framework for the Colombian Biodiversity Observation Network (BON) with the assistance of GEO BON and initiated the development of the BON including producing a national assessment of biodiversity monitoring tools using the Bon in a Box framework. The BON is now active with six research institutions and the Ministry of Environment formally involved. As well, a working group on subnational assessments and biodiversity observation systems is focused on developing and agreeing to specific conceptual models, indicators, and data collection protocols. The consolidation and progress of the Colombia BON can be seen as a pilot case for the CBD Parties as a whole. The overall process and approach for designing this national BON will be communicated as a CBD Technical Publication, which will be presented at COP12 in Mexico in 2016 showing the potential of GEO BON to serve as an applied provider of biodiversity observation expertise to the Parties of the CBD. The development of this pilot national BON will be closely aligned with existing efforts around the development of indicators for the Aichi Targets to ensure that the outputs of the national BON's directly serve these information needs.

## S3.10: Butterfly Monitoring Germany – the first ten years

**Elisabeth Kühn[1];** Alexander Harpke[2]; Martin Musche[2]; Reinart Feldmann[3]; Martin Wiemers[2]; Josef Settele[2]
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The inclusion of citizens into biodiversity assessments enables the analysis of global change and land use impacts over large spatial scales and long time periods. In 2005 a nationwide monitoring scheme for butterflies was launched in Germany which is hosted at the Helmholtz Centre for Environmental Research – UFZ. The project is supported by a large number of volunteers who are involved in data collection, regional coordination and data quality safeguarding. To further improve the monitoring scheme a questionnaire was sent out to all participants in our citizen science-project. We asked for age, gender and previous knowledge of the volunteers and wanted to better understand their motivation and demands for efficient communication (sending letters, data entry online, taking pictures). We will provide information on the structure and methods of the monitoring scheme and present the results of the questionnaire. We will explain the importance of a central coordination and regional coordinators. Further we will give a short insight into butterfly population trend analysis and discuss their applicability for nature conservation.

## S3.11: Biodiversity Monitoring and Reporting System Project in Taiwan (TaiBON) —Marine Aspect

**Kwang-Tsao Shao[1];** Mao-Ning Tuanmu Ying-Yueh Chin Yu-Huang Wang Guan-Shuo Mai Li-Hao Guan Chium-Tse Huang Yi-Chuan Cheng
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In accordance with the goals of the 2010 Biodiversity Target (2001-2010) and the Aichi Biodiversity Targets (2011-2020), the government has officially begun to promote the "Biodiversity Action Plan" since 2001. Established are 94 KPIs (key performance indicators) to help agencies implement their related tasks, write quarterly reports and evaluate executions. Although there are many quantitative indicators among these KPIs, none has been really evaluated and produced any trend graphs over the years. As a result, it's often difficult to grasp the changes in biodiversity and if the conservation work is effective. To remedy this situation, the Forestry Bureau of COA in 2014 commissioned the BRCAS to collaborate with its counterpart at National Taiwan University to begin a four-year "National Biodiversity Monitoring and Reporting System Project (TaiBON)." In addition to develop indicator system, propose new indicators and facilitate filling out information online by agency personnel, the system will automatically turn data to indicator values and generate trend graphs from quantifiable data in order to review and assess the effectiveness of conservation measures. The system can also provide material to produce national biodiversity reports in the future. Academia Sinica is in charge of adding and revising marine indicators; and contacting potential data-providing agencies, universities and NGOs to encourage them to open their existing long-term monitoring data, as well as providing them with guidance and assistance in navigating the reporting system later on. After much discussions and consultations in a number of meetings, 42 "Responses" and "State" candidate indicators from the four issues of overfishing, marine protected areas, marine pollution and abundance of focal marine species were selected in the first year. The actual construction of the system for the indicators with long-term data will be carried out in the second year. Since these marine long-term monitoring data fit into the goals and needs of the international GEO BON, it is hoped that Taiwan's TaiBON project can soon join GEO BON so that information can be integrated and shared. Let's strive for the conservation of biodiversity together.

## S3.12: Biodiversity observatory in Bolivia

**Miguel Fernandez**
German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig

At the intersection between several major biogeographic zones, Bolivia has extraordinary potential to develop a monitoring strategy aligned with the objectives of the Group on Earth Observations Biodiversity Observation Network (GEO BON). Since 2005, Bolivia has been working on the adequacy of national earth observations towards the objectives of the Global Earth Observation System of Systems (GEOSS). However, biodiversity is still an underrepresented component in this initiative. The integration of biodiversity into Bolivia's GEO framework would confirm the need for a country level biodiversity monitoring strategy, fundamental to assess the progress towards the 2020 Aichi targets. Here we analyze and discuss some aspects of the process related to developing such strategy. We focus on issues related to the acquisition, integration and analyses of multi-scale and multi-temporal of the most comprehensive biodiversity database for the country of Bolivia, containing more than 800 thousand species records referenced in time and space that account for 96% of the species previously reported for the country. We capitalize this information into recommendations for the implementation of the Bolivian Biodiversity Observation Network that will help ensure that biodiversity is sustained as the country continues on its path of development.

# S3.13: Using the EBV concept support biodiversity assessments within administrative boundaries

**Eren Turak**
NSW Office of Environment and Heritage

Accurate measurements of biodiversity change within boundaries of a country, state or other jurisdiction is critical for ensuring the effectiveness of legislation, policy and management actions aimed at conserving biodiversity.The aim of this paper is to present an approach for applying the EBV concept within administrative boundaries to address three main objectives: 1) meeting Jurisdiction-specific policy and management needs for measuring biodiversity; 2) comparing estimates of biodiversity change among jurisdictions; and 3) aggregating these estimates across multiple jurisdictions including at continental and global scales to help assess progress towards global biodiversity targets.
Three key requirements for applying the EBVs within political boundaries are: 1) feasibility of developing bioregion-scale qualitative models that link biodiversity attributes to threats and management actions for key ecological features 2) emergence of a set of variables that capture multiple dimensions of biodiversity and are shared by a great majority of models; and 3) the adequacy of available data to measure baselines and trends in those EBVs. We examined these requirements for the Australian State of NSW (801, 428 km2) in relation to State-wide priorities for biodiversity Assessments to support the Environmental Assessment, Monitoring and Reporting (EMAR) program, using Terrestrial, Freshwater and Marine Ecoregions of the World.
Current knowledge on ecological processes and threats in NSW, and evidence for links between pressures and biodiversity conditions may support development of qualitative models for about a third of the ecological feature-region combinations. This assessment implies that there was sufficient published evidence of cause and effect relationships between specific pressures and biological indicators to predict a positive and measurable response of these biological indicators to affective management actions within 1-5 year intervals. 14 of the 22 candidate EBVs were considered to include appropriate biodiversity surrogates in relation to major policy drivers and management actions in NSW. Matching of these variables to individual models, X variables from the EBV classes Species populations, ecosystem structure and ecosystem function were found to be common to all models. Existing biodiversity data may allow baseline estimates a majority of these EBVs within all bioregions. This is considered sufficient for reporting on baseline biodiversity condition in these bioregions in the near future. There would, be minor gaps in all regions and substantial gaps in others.
Existing biodiversity monitoring programs and ongoing collection of remote sensing data may allow annual trend assessments over the next five years to be made for a small subset of EBVs in most regions. The determination of existing models, knowledge of ecological processes and data adequacy, allows prioritisation of what needs to be done. For reporting on baseline biodiversity condition at the first instance , This first pragmatic step is to determine suitable indicators, the indices to be used and to determine to most efficient way of estimating these. Each model provides a hypothesis testing framework for EBVs and indicators within the Response-Pressures -Condition- Benefits model. We propose a generic framework for applying in any jurisdiction across the world and link this to new approach for jurisdiction-wide and regional biodiversity observation networks.

## S3.14: Development and Assessment of Taiwan's Biodiversity Indicators System

**Chiao-Ying Chou[1];** Chyi-Rong Chiou[1]; Ti-Yi Kuo[1]; Cheng-Tao Lin[2]; Li-Hao Guan[3]; Chium-Tse Huang[3]; Yi-Chuan Cheng[3]
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Biodiversity indicators are statistical measures of biodiversity which reveal the condition of biodiversity, the factors that affect them, and the progress and success of conservation policies. Successful biodiversity indicators can serve as an "early warning system" to detect the emergence of problems, to raise awareness of that, and put responses to that into context. In this study, the objectives are to 1) develop the criteria of selecting proposed national biodiversity indicators, 2) build the national biodiversity indicator development system, and 3) assess the proposed national biodiversity indicators in Taiwan. As a result, a two-tier indicator selection system is developed. The first tier is based on the framework of PSBR (pressure, state, benefit, and response) categories from BIP (Biodiversity Indicators Partnership). Second tier has four aspects, i.e., relevant to the issue, available data, sustainability, and internationalization, coming with six criteria, including relevant to user's needs, understandability, data with validity and reliability, practical monitoring system, competent authority, and international compatibility. Secondly, a national biodiversity indicator development system is modified from BIP to be capably adopted in Taiwan. Finally, three terrestrial issues, i.e., abundance and distribution of selected species, terrestrial protected area, and invasive alien species, along with 32 proposed indicators have been assessed. In conclusion, most indicators are categorized as state and pressure. There are few response indicators, but lack of benefit ones. When developing indicators, the indicators are generally built by available data, easily to be understood and relevant to user's needs, such as policy and management decision-makers. Some of the indicators are internationally compatible and supported by sustainable data providers. However, most indicators have apparent weakness on the practical and standard monitoring system, data quality and data accuracy, and authorities responsible for indicators' continued production and communication. Therefore, the development of national biodiversity indicators system is fundamental and crucial in Taiwan to assure the comprehensiveness and usefulness of biodiversity indicators. Most importantly, Taiwan's Biodiversity Observation Network (TaiBON) needs to be constructed on the base of the national biodiversity indicators system.

## S3.15: Up-scaling ecosystem assessments: a tool for the development of the National Biodiversity Strategy and Action Plan

**Patricia Koleff[1];** Tania Urquiza-Haas[2]; Sylvia Ruiz-González[2]; Andrea Cruz-Angon[2]
[1] CONABIO; [2] Comisión Nacional para el Conocimiento y Uso de la Biodiversidad

To implement appropriate policy measures and make innovative commitments to halt biodiversity loss and improve human well-being, decision makers need updated, scientifically sound and relevant information at appropriate scales. Innovative tools are needed to connect science and policymakers, promote actions towards sustainability and assess the progress of sustainable development goals, including Aichi targets and the development of National Biodiversity Strat egies and Action Plans. Among those tools, national assessments are a key element to identify knowledge gaps in different sectors and guide strategic actions for sustainability. In 2005, a major effort of this type was launched in Mexico (Capital Natural de México, CNM). This was a country-level assessment on the state of knowledge on the different components, structure, and functioning of biodiversity, its conservation status and threats and trajectories of anthropogenic impact, as well as policies, institutions, and instruments needed for its sustainable management. CNM provided and unprecedented work of data systematization, reflection and analysis. In this work we describe the way by which CNM provided a strong scientific foundation that is policy-relevant for the development of the National Biodiversity Strategy and Action Plan in Mexico.

## S3.16: Implementing and integrating terrestrial biodiversity indicators throughout New Zealand

**Peter Bellingham[1];** Elaine Wright[2]; Sarah Richardson[1]; Andrew Gormley[1]; Robbie Holdaway[1]; Kate Orwin[1]; Adrian Monks[1]; Philippa Crisp[3]
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New Zealand is a global biodiversity hotspot with high endemism (e.g., 85% of the vascular flora). Its biodiversity is under pressure from biological invasions, land use changes, and climate change. Central and regional government agencies in New Zealand have developed terrestrial biodiversity indicators in response to national and international requirements to report status and trends in biodiversity. The indicators develop correspond closely with most recommended Essential Biodiversity Variables (EBVs). Indicators of species populations and community composition have been implemented, since 2011, across 8.6 million ha (one-third of New Zealand's land area, public land designated for conservation). Concurrent measurements of indicators of plant communities, bird communities, and of some non-native mammals are conducted at sample points located systematically at the intersections of an 8-km × 8-km grid superimposed across New Zealand. These reveal greater abundance of native birds than non-native birds in some forest types but not in shrublands and non-woody ecosystems. They show substantially different patterns of distribution and abundance among non-native mammals. Repeated measurements of plant communities from the same sites, conducted since 2002, allow estimates of change. These show that populations of trees that are consumed preferentially by introduced mammals show greater levels of mortality than recruitment over the last decade. Long-term ecological records support other EBVs; for example, phenological traits to support species traits include annual records of seed production of some dominant native trees and grasses that extend across environmental gradients and include some records >40 years. A current challenge is to extend implementation of terrestrial biodiversity indicators across private land, including agricultural landscapes, plantation forests, and urban ecosystems. The same indicators used on public conservation land have been implemented since 2014 in one region. New environmental-DNA-based indicators of belowground biodiversity and plant communities have been implemented, along with measures of ecosystem function (microbial respiration and standardized measures of decomposition, on the same systematic sampling grid across all land.

# S3.17: Connect: Mainstreaming biodiversity information into the heart of government decision making

**Nadine Bowles-Newark**
UNEP World Conservation Monitoring Centre (UNEP-WCMC)

The Connect project aims to ensure biodiversity is taken into account in policy frameworks across government sectors by improving decision makers' access to and use of biodiversity information and embedding biodiversity information within national decision making processes. The project is a UNEP-WCMC-led initiative, supported by GEF Global funding, which is set to take place over a four year period, working deeply within three demonstration countries within Sub-Saharan Africa: Ghana, Mozambique and Uganda. This presentation will inform GEO BON members of the project, allowing for the discussion and exploration of the most effective and coordinated means to implement aspects of the Connect project in coordination with GEO BON and its partners.

Connect Project summary:

A great deal of the world's biodiversity has already been lost; this is a well-substantiated global environmental problem, with considerable consequences for human well-being. Biodiversity and ecosystem services are essential components of a healthy economy, relevant not only to the environment sector but across all sectors of society. Loss of biodiversity and impacts on ecosystem services through human activities has consequences across a number of sectors, as actors find it more difficult to achieve their own objectives and aspirations, including for development and poverty reduction.

In order to change this situation, government decision makers need to have access to biodiversity information that helps them to understand the potential impacts of the decisions that they are taking. At the same time, biodiversity data and information providers also require an improved understanding of decision making processes, and how biodiversity information can be most effectively integrated into those processes both now and in the future.

The Connect project will help governments to achieve sustainable development by bringing biodiversity and ecosystem services to the heart of government decision making using actionable biodiversity and ecosystem services information. It focuses on in depth development of proofs of concept with a small number of carefully selected countries to:

1. Clearly understand the in-country demands for, and the barriers to using, biodiversity information within government decision making including clarifying the format, timing and packaging required
2. Mobilise and repackage existing biodiversity data and information from a range of sources (national and international) to meet a number of the above demands; and
3. Strengthen the connection between government decision makers and biodiversity and ecosystem services data providers in order to sustainably provide policy-relevant, spatially explicit information to meet ongoing national needs.

The outputs will be demand-driven, based on country-specific cross-sectoral government information needs for decision making (Component 1 - Demand). Each country will develop and trial innovative mechanisms for re-packaging existing biodiversity information into the appropriate formats (Component 2 - Supply). Learning from these innovative solutions, the approach will be applied globally, to facilitate the provision of demand-driven biodiversity information to 1) decision makers in other countries and 2) facilitating countries' reporting to Multilateral Envi-

ronmental Agreements (MEAs: also Component 2 - Supply) and other international and regional policies and processes. Component 3 - Sustain will focus on embedding and integrating biodiversity information into cross-sectoral government systems and processes now and into the future. In addition to improving government decision making, the project will improve the ability of governments and the international community to report progress against many of the Aichi Targets, and in particular will help to achieve Aichi Target 19 (knowledge, the science base and technologies relating to biodiversity, its values, functioning, status and trends, and the consequences of its loss, are improved, widely shared and transferred, and applied) and Aichi Target 2 (biodiversity values have been integrated into national and local development and poverty reduction strategies and planning processes and are being incorporated into national accounting, as appropriate, and reporting systems).
Globally, the project will:
• Improve the understanding amongst the international biodiversity community of the types, format, packaging and delivery of biodiversity data and information that is required for decision-making at the national level.
• Develop decision-appropriate biodiversity and ecosystem services data and information products that feed specific needs of national data users within government decision-making processes.
• Pilot these information products through 3 carefully selected national demonstration cases (Uganda, Mozambique and Ghana) while working with an International Technical Advisory Group (ITAG) to ensure global relevance.
• Develop a theory of change for biodiversity mainstreaming, drawing from a review of previous cases where there has been an attempt to use biodiversity information for mainstreaming, or integration of biodiversity information into decision making.
• Test this theory of change through the demonstration cases to provide a common frame of reference for the design of future interventions to be funded by GEF and other funding bodies.

## S3.18: The Biodiversity Indicators Partnership, supporting national indicator development

**Anna Chenery**
UNEP World Conservation Monitoring Centre

The CBD-mandated Biodiversity Indicators Partnership (BIP) is a global initiative to promote the development and delivery of biodiversity indicators for use by the CBD and other biodiversity-related Conventions, for IPBES, for reporting on the Sustainable Development Goals, and for use by national and regional governments. One of the main objectives of the BIP is to strengthen capacity at the national level for indicator development and use in implementation and reporting of National Biodiversity Strategies and Action Plans (NBSAPs) and the SDGs. To date, the BIP has supported biodiversity indicator capacity building in over 60 countries and developed a range of resources to support national practitioners in the identification, design and development of indicators.
In 2014, the BIP published a roadmap to support the utilisation of the global indicators and underlying data for the development and implementation of National Biodiversity Strategies and Action Plans (NBSAPs). The publication served to create awareness of the possible use of the BIP global indicators, which are often aggregated from national level data and guide national

biodiversity practitioners in the use of these indicators in the development and implementation of NBSAPs. Following the launch of this publication, there has been an increased call by Countries for access to global indicator methodologies and disaggregations to support their national implementation and reporting for the CBD. The BIP will play an active role in supporting these requests.

## S3.19: Stepping-stones towards a common framework to assess and report High Nature Value farmlands in the EU countryside

**Ângela Lomba**
CIBIO-InBIO

Shaped historically by farmers and farming practices, many EU landscapes are currently dominated by agriculture. Due to the recognized role in the maintenance of biodiversity and its habitats, extensively managed farmlands – High Nature Value farmlands, HNVf - have been highlighted by scientists and policy-makers as critical to protection of the rural environment by enhancing resilience and providing ecosystem services.
While the backbone characteristics of HNVf have been recently reviewed, caveats still persist for a consistent implementation of the concept e.g. the scarcity of adequate datasets on biodiversity, land cover and land use, together with the lack of tested, standard approaches to mapping and indicator estimation. Additionally, difficulties in the establishment of a HNVf baseline hamper the EU's ability to quantify the condition and dynamics of such farmlands, and thus to anticipate impacts of future environmental changes on rural landscapes.
Here, results from ongoing case-studies focusing the dynamics of HNV farmlands in space and time will be presented. By considering several levels of 'natural value' e.g. provision and dynamics of ecosystem services, and accounting for their vulnerability and resilience in the face of uncertain future, our results are expected to contribute to the optimization of the design, implementation and evaluation of rural development programs. We expect that this would foster the EU strategy of positively discriminating and supporting farmers in their efforts to ensure the conservation and improvement of biodiversity and ecosystem services in the context of economic and socio-ecological change.
This research is part of the project FARSYD- POCI-01-0145-FEDER-016664 (PTDC/AAG-REC/5007/2014), supported by Norte Portugal Regional Operational Programme (NORTE 2020), under the PORTUGAL 2020 Partnership Agreement, through the European Regional Development Fund (ERDF). A. Lomba is supported by the Portuguese Science and Technology Foundation (FCT) through Post-Doctoral Grant SFRH/BPD/ 80747/2011.

# Session 4: Thematic and Regional BONs

## S4.1: Freshwater long-term ecological research (LTER): Challenges, obstacles and opportunities

**Peter Haase**
Senckenberg

The multitude and complexity of global change effects on biodiversity and human wellbeing call for long-term environmental data as a basis for science, policy and decision making. Such data is provided by a number of site-based long-term ecological monitoring initiatives, such as the global long-term ecological research (LTER) network with over 600 LTER sites. An important conceptual backbone of LTER is the Ecosystem Integrity concept. This concept is basically a holistic approach to describe an ecosystem covering both biotic and abiotic parameters. Yet, as LTER at its core is a bottom-up initiative, the parameters measured differ grossly among sites. With more than 100 sites the freshwater realm is comparably well-covered. Based on the example of the LTER site Rhine-Main-Observatory (Germany) the overall approach of a freshwater LTER site will be presented. Finally, opportunities of how to link LTER monitoring with other global initiatives like GEO BON will be outlined. This will maximize synergies in the use of costly infrastructures and foster cross initiative research.

## S4.2: Applications of long-term monitoring freshwater biodiversity data in species distribution modeling

**Mathias Kuemmerlen;** Stefan Stoll; Andrea Sundermann; Peter Haase
Senckenberg

Data stemming from long-term monitoring schemes deliver accurate time series with precise information on the spatial distribution of species. These properties make monitoring datasets highly advantageous for species distribution models (SDMs), because they solve some of the major issues concerning the occurrences frequently implemented: the heterogeneity of non-standardized sampling. With the robust groundwork of long-term monitoring data, SDMs can be applied to address a large variety of ecological questions: small-scale distribution patterns, impacts of individual stressors, projections of future distributions under environmental change scenarios and addressing local conservation planning. Furthermore, results from SDMs have uncovered “blind spots” in monitoring schemes, which can be used to complement and further improve the collection of long-term data sets. This has sparked the development of SDM-based tools to plan and evaluate field sampling. Conversely, data from monitoring has been applied to explore new approaches in SDMs. We present examples of SDM applications using data from the long term ecological research site Rhine-Main-Observatory in central Germany and discuss how interactions between monitoring and modeling can drive a process of mutual improvement. The examples presented are based on freshwater ecosystems, but can be widely applied to other realms.

## S4.3: FreshWater Watch, a global study of aquatic ecosystem health using citizen science

**Ian Thornhill;** Steven Loiselle
Earthwatch Institute

FreshWater Watch is a global citizen science project carrying out research into lentic and lotic freshwater ecosystems. To date, in excess of 13,000 datasets have been collected in over 30 countries. Following a globally consistent training programme conducted by local research partners, citizen scientists support local scientific research by collecting hydrological, ecological and chemical data related to freshwater quality and ecosystems. The data are uploaded to an online database using smartphone technologies. The platform itself provides a range of feedback to the individual and promotes a community of FreshWater Watchers who are free to ask questions, post blogs or engage further.
An international team of scientists are currently using the FreshWater Watch data to explore and compare the driving factors of freshwater ecosystem dynamics with respect to differences in climate, land use and catchment conditions. Preliminary results suggest population density, land cover and precipitation are key factors controlling aquatic ecosystem dynamics. Furthermore, data from across the globe indicate that smaller water bodies present better ecological conditions than larger waterbodies. The use of micro scale citizen science data such as the presence, absence and composition of bankside or instream vegetation and water colour, together with macro scale satellite and remote sensing information enhances the ability of practitioners to identify potential areas of concern. FreshWater Watch provides an integrated approach to address and involve new audiences in data collection, interpretation and stewardship, which is key to ensuring the sustainable use of our freshwater resources.

## S4.4: Data needs and priorities for measuring essential biodiversity variables in freshwaters

**Eren Turak**
NSW Office of Environment and Heritage

A critical requirement in assessing progress towards the 2020 Aichi Targets of the Convention on Biological Diversity (CBD) is improving the capacity to measure changes in biodiversity globally. That global biodiversity declined between 2000 and 2010, and the decline was greater in freshwater than in terrestrial or marine systems. However, the data, tools and methods available during that decade were inadequate to reliably assess the extent of the reduction in global freshwater biodiversity. Recent advances in freshwater monitoring make a global assessment now close to becoming feasible. Here we present an Essential Biodiversity Variables (EBV) framework to identify priorities for 2020 and 2030 that will help a global assessment. Priorities for 2020 include the generation of global maps of change in biodiversity condition for variables under three of the EBV classes (species populations, community composition, and ecosystem structure), by 2020 using a Red List Index with expanded geographic and taxonomic cover, an improved freshwater Living Planet Index with a greater number of species, measures of alpha and beta diversity, and globally-consistent estimates of wetland extent. To assess variables in the other EBV classes (genetic composition, species traits, and ecosystem function) we must prioritize development of environmental DNA methods, species-traits databases, eco-informatics and modelling over the next 15 years. Actions based on all of these priorities will require urgent and coordinated effort by scientists, governments, non-governmental organizations, the private sector, and others to collect, process, analyse and interpret the data. These analyses will provide important information for international treaties and intergovernmental bodies (e.g. CBD, Ramsar) that may also help secure resources needed to implement these actions

## S4.5: Freshwater Key Biodiversity Areas in the Eastern Mediterranean Biodiversity Hotspot

**Jörg Freyhof**
German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig

Through a two year study involving scientists from across the region, the status of freshwater biodiversity in the Eastern Mediterranean has been shown to be in an alarming state. With almost one in five species threatened with extinction, and number of species already extinct urgent action is required to restore and protect wetlands and flow regimes, and adopt integrated water resource management practices that incorporate biodiversity needs.
That region of the world is facing significant levels of water stress and there is often a perceived dichotomy between the provision of water for people (or irrigation etc.) and the 'environment' (biodiversity). When faced with this choice the needs of biodiversity are, at best, usually only considered if there is any water 'remaining' once all other uses have been catered for. The notion that healthy freshwater ecosystems (functioning as 'natural infrastructure') that support biodiversity will provide, store, and purify water, and also provide many other valuable ecosystem services (e.g. food, flood protection, recreation etc.) is not widely appreciated. In addition the information required to inform this decision making process about the needs of biodiversity is usually lacking.

## S4.6: The Satellite-based Wetland Observation Service (SWOS) – Wise use of wetlands supported by Earth observations

**Kathrin Weise[1];** Christian Huettich[1]; Eric van Valkengoed; Jonas Franke; Susanne Thulin; Jonas Eberle; Christoph Schröder; Dania Abdul Malak; Adrian Strauch; Eleni Fitoka; Anis Guelmami; Eric Mino; Stephan Flink; Lammert Hilarides; Fiona Danks; Anouska Plasmeijer
[1] Jena-Optronik GmbH

Wetlands are one of the fastest declining ecosystem types worldwide, while at the same time they are hot spots of biodiversity and provide diverse and valuable ecosystem services; such as water supply, hydrological buffering against floods and droughts, and climate regulation through carbon storage. Information on wetland extent, their ecological character and their services is often scattered, underestimated and difficult to find and access, which leads to the fact that wetlands are only partially covered worldwide by policies and management practices.
In this respect, SWOS (a Horizon-2020 project funded by the European Union) provides monitor

ing tools and information on wetland ecosystems, mainly derived from Earth Observation data. SWOS is assisting with reporting and monitoring obligations stemming from environmental policies at different scales (from local to global), which contributes to an improved integration of wetlands in policy. SWOS also contributes to the development of a Global Wetland Observation System (GWOS) in close cooperation with the Ramsar Convention on Wetlands, the Group on Earth Observations (GEO) and other international partners and it complements the MAES process under the EU Biodiversity Strategy to 2020 by supporting the maintenance and restoration of wetland ecosystems and their services. Ultimately, SWOS allows for the informed creation of conservation and restoration measures which maintain biodiversity and essential ecosystem services.
The objective of SWOS is to prepare and install an operational service with users for users. Several user organizations are represented by the SWOS Consortium, and further users are identified at the global (e.g. GEO/GEOSS, Ramsar, EU, CBD), regional, national (e.g. EU member states, WFD, national administrations, Natura2000) and local (protected area managers, scientists, local administrations) level in order to support a multi-level user approach. Service cases will demonstrate opportunities for improved wetland management, planning and decision making. SWOS focuses on the use of freely available satellite data from ESA's Sentinel satellites and Landsat archives, and builds on results of ESAs Globwetland projects. Near real-time observations via the SWOS service portal allow for dynamic monitoring of wetland status and changes (and the drivers of those changes) on a large spatial and temporal scale. The service will be demonstrated on a selection of wetlands in Europe, but also in Africa and Asia.
The SWOS service portal is a "knowledge hub", allowing users to gain access to a wide range of information for each wetland, including spatial mapping products, scientific papers, links to external webpages, documents, images, etc.. In addition the portal provides the on-demand processing of indicators or information based on the mapping products.
This presentation provides an overview of the SWOS approach as well as gives insights into how the project is engaging users through the establishment of user groups and the development of service cases. The portal and mapping software will be presented together with first monitoring and mapping results.
(for more information swos-service.eu)

## S4.7: Towards a Global Wetland Observation System

**Adrian Strauch[1];** Stephan Flink[2]; Nobuyoshi Fujimoto[3]; Gary Geller[4]; Ania Grobicki[5]; Lammert Hilarides[2]; Javier Muro[1]; Marc Paganini[6]; Ake Rosenqvist[3]; Kathrin Weise[7]
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Wetlands are one of the fastest declining ecosystem types worldwide, while at the same time they are hot spots of biodiversity and provide diverse and valuable ecosystem services, such as water supply, hydrological buffering against floods and droughts, and climate regulation through carbon storage. Information on wetlands extent and their boundaries is often scattered and difficult to find and access, which leads to the fact that wetlands are only partially covered worldwide by policies and management practices. To improve this situation, the Ramsar Convention on Wetlands has been supporting the conceptualization of a Global Wetland Observation

System (GWOS) since 2007. Starting from 2011 the Biodiversity Observation Network (GEO BON) of the Group on Earth Observations (GEO) is coordinating this effort.
The recent launch of the "Satellite-based Wetland Observation Service" (SWOS) Horizon 2020 Project, offers new opportunities and initial funding for development and implementation of the GWOS. Based on the results of the ESA GlobWetland 1 & 2 projects, SWOS is strongly focused on using new Satellite data from Sentinels 1-3 and combining it with other satellite data (MERIS, MODIS, Landsat) as well as ground data and existing data sources from different disciplines (e.g. hydrology, ecology, agriculture/land use, climate). The SWOS project will develop web-based infrastructure for standardized visualization, analysis, download and exchange of wetland observations and information and therefore provide an important baseline for a global system. The JAXA Global Mangrove Watch (GMW) initiative furthermore constitutes a pilot project to the GWOS, where fine resolution baseline and change maps, generated over all global mangrove regions from JERS-1, ALOS and ALOS-2 satellite (L-band SAR) data, are foreseen to be made available to wetland stakeholders though the GWOS. GlobWetland Africa is another important GWOS pioneering project funded by ESA in close collaboration with the Ramsar secretariat, which will develop a comprehensive, open-source and free of charge software toolbox for the production of wetland maps and indicators derived from freely available satellite data sources (e.g. Sentinels 1-3, Landsat 5-8, ALOS PALSAR). Together with other running and upcoming wetland related projects, there is a great opportunity for demonstrating the potential and benefits of a GWOS to stakeholders and decision-makers through products and service-cases. Multi-level (local to global) service-cases are developed within these projects in a stakeholder- and user-driven way and highlight the policy- and decision-making relevance of a GWOS. National wetlands inventories could benefit immensely from the functionalities and information products provided by the mentioned projects and a GWOS, which will also contribute towards future regional and global assessments for the Ramsar State of the World's Wetlands Reports, as well as the global-level monitoring of the relevant Aichi Biodiversity Targets and Sustainable Development Goals (for both water and biodiversity under Target 6.6 and Target 15.1), and their indicators regarding wetlands extent.
The mentioned projects together with GEO BON, GEO Water, the GEO Secretariat, the Ramsar Secretariat and other key stakeholders constitute a core partnership to coordinate the further progress and implementation of the GWOS by connecting relevant ongoing activities and by developing a roadmap and implementation plan for a GEO-Wetlands Initiative. The development of a GWOS is one of the main goals of the newly proposed GEO-Wetlands Initiative within the framework of the GEO Work Programme 2017-2019.
Building on the SWOS infrastructure and including the tools and products developed in former and current projects as well as regional and national monitoring and assessment programs will bring the GWOS a big step closer towards implementation. One goal of the GEO-Wetlands Initiative is to secure long-term funding for the maintenance and further development of an operational, user-driven GWOS that exists beyond the runtime of contributing projects. To achieve this, GEO-Wetlands is expected to play a key role in the coordination and facilitation of global, regional and national wetland EO activities, and to use its convening power to integrate different communities and activities in this global effort. Finally, the implementation of an operational GWOS can be seen as a major contribution to the further development of the GEOSS.

## S4.8: Lessons learned from the freshwater biodiversity data mobilisation activities for the Freshwater Information Platform

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[1] Royal Belgian Institute of Natural Sciences; [2] University of Natural Resources and Life Sciences, Vienna; [3] Leibniz Institute of Freshwater Ecology and Inland Fisheries (IGB)

In the framework of the EU FP7 BioFresh project (Biodiversity of Freshwater Ecosystems: Status, Trends, Pressures, and Conservation Priorities) and the continuation of its activities under the umbrella of the Freshwater Information Platform, we engaged in a wide range of data mobilisation activities. We focused our efforts on freshwater biodiversity data, which is crucial for improving our understanding of species distribution and threats, especially as freshwater environments are heavily affected by the global biodiversity crisis.
We encouraged data publication through: (a) documenting freshwater related datasets in a metadatabase, (b) promoting data papers, (c) assisting data holders to submit data and (d) demonstrating the use of these datasets for large-scale analyses and models. Although this contributed to the improved data availability for specific organism groups and geographic regions (notably European fish data), we argue that much more should be done to ensure that a critical mass of existing freshwater data becomes publicly available. We believe that there is an urgent need to adopt a systematic approach towards on-line data publication. The development of (institutional) data policies and management plans that foresee public release of data upfront, exchange of expertise in this area, and the systematic submission of biodiversity data associated with published papers represent a significant step in this direction.

## S4.9: The Global Freshwater Biodiversity Atlas as a tool for mobilisation of freshwater biodiversity related large-scale geographical information

**Vanessa Bremerich[1];** Aaike De Wever[2]; Astrid Schmidt-Kloiber[3]; Jörg Freyhof[4]
[1] Leibniz-Institute of Freshwater Ecology and Inland Fisheries, IGB; [2] Royal Belgian Institute of Natural Sciences; [3] University of Natural Resources and Life Sciences, Vienna; [4] German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzi

To help understand patterns of freshwater biodiversity, its current status and future trends as well as to protect and manage threatened freshwater species and ecosystems, access to large-scale geographical information is needed. To support this demand we developed the Global Freshwater Biodiversity Atlas as part of the Freshwater Information Platform during the EU funded FP7 project BioFresh (2010-2014), together with the GEO BON Freshwater Ecosystem Change Working Group and associated partners (IUCN Species Survival Commission, Global Water System Project, Wetlands International, Conservation International, The Nature Conservancy and the World Wildlife Fund).
The Atlas is an interactive online mapping platform that was developed using Open Geospatial Consortium (OGC) compliant open-source technologies and standards. Map layers are provided as Web Map Services (WMS) that can be reused in other GIS applications. Thematic maps on freshwater biodiversity and species distribution patterns together with key geographical background information on freshwater ecosystems, environmental variables, pressures linked to climate and land use changes, the identification of conservation priority areas or other larger-scale synthesis maps are published under a Creative Commons license and accompanied by

short explanatory articles.
Publishing open access online maps through the Atlas benefits contributors by improving the visibility and accessibility of their research results. Researchers and funders are credited for their work by linking back to their institutions and projects, related publications and related data- or metadata sets. Members of the scientific community, conservation planners, policy makers, and the wider public can use the visualisations and texts for their respective needs, if they provide the required attribution.
As a further step, we encourage map contributors to make the underlying spatial data available for download, so that they can be used in follow-up studies, as reference or input layers for further research or be combined with other data to perform larger-scale analyses. To facilitate the preservation and reuse of geographical data associated with published papers, it is mandatory that they are well documented and made available for download using standard data and metadata formats. To this end, we implemented a general geodata management system in the Freshwater Information Platform that directly links the Global Freshwater Biodiversity Atlas, the Freshwater Metadatabase and the Freshwater Biodiversity Data Portal.

## S4.10: Panel discussion on freshwater and wetland biodiversity monitoring and data mobilisation

**Aaike De Wever[1];** Ian Harrison; Marc Paganini; Klement Tockner; Walter Jetz
[1] Royal Belgian Institute of Natural Sciences

To close the “4.05 Freshwater and wetland biodiversity monitoring and data mobilisation” session, we organised a panel discussion with a wide range of experts with experience in various monitoring and data mobilisation. At this stage we received confirmations from Ian Harrison (CI, IUCN, GEO BON WG4), Marc Paganini (ESA), Klement Tockner (IGB, Freshwater Information Platform), Walter Jetz (Yale University, Map of Life), but we are still inviting other panel members who are interested to contribute to the discussion.
Topics we want to address during the discussion include: What are the major gaps in the monitoring of freshwater and wetland environments? How can remote sensing complement on-the-ground monitoring in identifying and filing those gaps? What are the major existing datasets that remain to be mobilised and publicly released? How can we ensure that data mobilisation work answers the needs of large scale modelling work and helps addressing urgent policy questions?

## S4.11: The Thematic Marine Biodiversity Observation Network (MBON)

**Frank Muller-Karger**
University of South Florida

Mission: Understanding the Impacts of Changing Life in the Ocean
The Thematic MBON facilitates the identification of useful indicators of change in the living ocean. Changes in communities, species and habitats are indicators of environmental change relevant to ecosystem services and the well-being of humanity.

The Thematic MBON grows out of the priority activities of the GEO BON WG5. It includes and builds on the Global Marine Ecosystem Mapping effort. It incorporates the biodiversity priorities of various GEO initiatives, including Blue Planet and AmeriGEOSS, and coordinates with IOC/UNESCO (GOOS and I-OBIS), and other national and international groups to serve the broadest possible community. The MBON will help nations and regions to improve conservation planning and environmental impact mitigation, serve the scientific community, and satisfy commitments to the Convention of Biological Diversity (CBD) and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES).
Workshop Focus:
1) Document the benefits of an MBON (goal - list and document examples of the practical benefits of marine biodiversity observations)
2) The essential elements of a Marine BON (MBON): what are the minimum observational requirements to address a minimal set of essential variables?
- Propose a pilot use of 1-2 consistent variables across programs
3) Discuss practical definitions of biodiversity, strengths and weaknesses [I would steer clear of definitions and steer towards the reality of what aspects of biodiversity can be measured, and in what parts of the ocean system are these measurements possible. Instead I would focus on what we can measure or databases that can presently be used to contribute understanding to biodiversity status, change and response, which require information on drivers (temperature, productivity), and relevant scales of mechanistic processes, and then responses, i.e., compiled information on jellyfish blooms: JEDI, compiled species observations: OBIS, experimental networks: ZEN, quantitative surveys: RLS, compiled time-series data: BIOTIME, coral reef bleaching, etc.].
4) Database capabilities and needs.
5) Contribute to the BON in a BOX [e.g. examine the approach adopted for terrestrial systems, like the Living Planet Index, and ask what we can use or do differently in marine systems]
6) Develop a plan to transition the MBON into an operational system through partnerships with the U.S. Government and others.
WG5 Thematic MBON Workshop Outcomes:
1) Steps toward an implementation plan
2) An outline of a manuscript providing a vision for a global MBON, steps to accomplish this, and highlighting the need and benefits of an MBON.
3) List of EOVs and EBVs that all programs should monitor
- What baseline information/observations should be put in place NOW
4) Strategy to build a list of extreme events (coral bleaching, jelly fish blooms, algal blooms, etc.), biodiversity change (richness gains/losses), etc. These biological processes of interest would serve to have test cases for metrics (this follows the framework: http://geobon.org/essential-biodiversity-variables/ebv-classes-2/).

## S4.12: Mapping marine ecosystems, biogeographic realms, and other regionalisations

**Mark Costello[1];** Roger Sayre[2]; Zeenatul Basher[2]; Dawn Wright; Sean Breyer; Kevin Butler
[1] University of Auckland; [2] USGS

The world's oceans have long been mapped by coastal features, political boundaries and ad hoc management areas. Recently, biogeographic realms based on species endemicity have been proposed representing the long-term evolutionary history of species, and marine ecosystems ('Ecological Marine Units') have been derived from analysis of recent environmental data. Biodiversity includes both species and their ecosystems. A comparison between the boundaries of realms and ecosystems will indicate what environmental gradients have most strongly influenced the evolution of biodiversity by being barriers to species dispersal. This will inform as to what regions (realms and ecosystems) may be the most suitable for environmental management because of similar environmental conditions and species composition (i.e. biodiversity). Alternative regional mapping systems may complement or be useful for other purposes.

## S4.13: Developing Essential Biodiversity and Ocean Variables, and a Biodiversity Observation Network, for Coral Reefs

**David Obura[1];** Frank Muller-Karger[2]; Ruth Gates[3]; Mark Costello[4]; Nicholas Bax[5]
[1] CORDIO East Africa; [2] University of South Florida; [3] University of Hawaii; [4] The University of Auckland; [5] CSIRO, Hobart

Coral reefs are among the most biodiverse ecosystems in the oceans and on land, as well as being among the most important for the services provided to people. At the boundary between land and sea, they also face intense and growing pressures driven by population and economic growth in the tropical countries, most of them developing, that host them. Their vulnerability is illustrated by a major global coral bleaching event currently underway from 2015 into 2016, that may have greater impacts on reefs than the first global bleaching event in 1997-98. While monitoring of coral reefs occurs at many individual locations, integration of monitoring and reporting efforts at regional and global scale has not yet been achieved
A global framework for coral reef monitoring and reporting exists in the Global Coral Reef Monitoring Network (GCRMN), under the International Coral Reef Initiative (ICRI). With the emerging interest in global biodiversity observing systems under GEOBON, the plans to implement an international Thematic Marine Biodiversity Observation Network (MBON), and the Global Ocean Observation System's Biodiversity and Ecosystems Panel (GOOS-BioEco), the GCRMN is undertaking a process to strengthen and mature its procedures. This includes identification of Essential Biodiversity and Ocean Variables (EBVs and EOVs), improving standards to meet the GOOS Framework for Ocean Observations (UNESCO 2012) and to establish a coral reef BON (within the framework of MBON), and doing this in a DPSIR framework that addresses societal drivers of change and priority outcomes, and informs potential responses to mitigate negative impacts.
To achieve this, a 4-year action plan is being developed (2017-2020), starting with a consultation in the coral reef science community (online and in a Town Hall meeting) at the International Coral Reef Symposium, 19-24 June 2016, in Hawaii. This consultation will identify potential variables under all six EBV classes identified by GEOBON (genetics, species, traits, community, ecosystem function and structure), assessing the degree of global coverage and maturity of their observing systems against GOOS and GEOBON criteria. Those variables that can be supplied by the GCRMN observing system will be brought into a GCRMN development plan, those needing other methods and systems will be put through feasibility studies for maturing them to mature EBV status, and new/innovative research opportunities will be identified.
This information will be compiled and presented at the GEOBON Open Science Conference, and in the All Hands meeting Thematic MBON workshop a workplan will be developed for the

GCRMN development process, focused on strengthening the EBVs and establishing a coral reef BON. The scientific development components of the workplan will form the terms of reference for a proposed SCOR Working Group.

## S4.14: Cross shelf benthic biodiversity patterns in the southern Red Sea: setting up background levels for future monitoring of coral reefs and soft-sediments

**Susana Carvalho[1];** Holger Anlauf; Saskia Kuerten; Diego Lozano Cortes; Zahra AlSaffar; Joao Cúrdia; Burton Jones; Joanne Ellis
[1] King Abdullah University of Science and Technology - KAUST

The Red Sea is a narrow, semi-confined body of water that experiences high salinities and temperatures due to its geography and high evaporation rates making the region a natural laboratory to study community structure in warm, saline and oligotrophic waters. During the last decades, Saudi Arabia has experienced intense urban and industrial development with the flourishing of revenues from petro chemical industries. However, compared to other regions, limited information of the marine communities inhabiting this area. The assessment of current biodiversity baselines provides, however, an important tool to better understand the species richness in the region, the economic value of biodiversity and alterations of ecosystems services due to changes in biodiversity patterns. This is one of the few studies investigating simultaneously the composition and structure of macrobenthic communities from coral reefs (13 sites; 3-5m, 7-10m) and soft-sediment habitats (14 sites) along a cross shelf gradient. It was carried out in the Farasan Islands (southern Red Sea), a Marine Sanctuary where a considerable proportion of its inhabitants engage in fishing. This is a very interesting area given that the main source of nutrients into the Red Sea, coming from the Indian Ocean through the Gulf of Aden. Large industrial complexes and intensive agriculture also contribute to anthropogenic nutrient enrichment nearshore, and previous studies reported the destruction of benthic habitats due to bottom trawling. Coral reef assemblages differed significantly in species composition, size frequency distribution and structure with location and depth. Inner-shelf reefs harbored less abundant and less diverse soft and hard coral assemblages with higher macroalgae cover than outer-shelf reefs. The size-frequency distributions of near-shore coral populations exhibited negative skewness, which has been associated with unfavorable environmental conditions. Those changes were associated with nutrient availability and distance from the shoreline and indicate a potential impoverishment of these reef assemblages driven by human-activities in the near-shore region. As well as elevated nutrient enrichment in the coastal zone, there is also the potential for elevated turbidity in the nearshore southern Red Sea. This is due to the wider coastal shelf in the southern region where sediments are less readily lost to deeper water. The shallow bathymetry created by these sediment deposits in the southern Red Sea combined with their fine nature results in substrate instability and associated turbidity in exposed conditions, which can limit the opportunity for the development of coral reefs. Inshore sites dominated by macroalgae and showing relatively low hard coral cover contrasting to much higher coral cover and diversity in offshore sites have been reported for other reef systems in Australia and the US. Such shifts also highlighted in the present study indicate that both hard coral and macroalgae cover associated with nutrients are good bioindicator candidates for the future monitoring of

Red Sea reefs. The community composition and diversity of soft-sediment macroinvertebrates also changed from near-shore to offshore. The highest diversity and abundance of soft-sediment communities were, however, recorded near-shore. These sites were also characterized by a higher number of opportunistic polychaete and bivalve species in general, as well as lower equitability, which may be indicative of mild disturbance. A peak of opportunistic species is often associated with mild disturbance such as organic enrichment as summarized in Pearson & Rosenberg's (1978) seminal review of the effects of organic enrichment and pollution on marine benthic communities. Currently, the high levels of diversity and abundance observed in the inshore Jazan area appear to support the hypothesis that the system is affected by mild enrichment. The region is not, however, in a highly disturbed state where overall species richness is reduced and only high densities of small fast growing opportunistic species occur. In general, the macrofaunal species diversity recorded in this study was high, especially considering the taxonomic resolution of the study. Increasing the taxonomic resolution and expanding the spatial coverage of research in the Red Sea is likely to substantially increase the current number of macrofaunal taxa recorded supporting the overall high biodiversity previously reported for this region. Sediment composition and distance to the shoreline were important variables explaining the macrobenthic patterns of variability. This study provides novel information of regional biodiversity trends for both soft-sediment and coral reef ecosystems in an oligotrophic area, and assesses key environmental parameters related to these observed patterns of variation. Given the characteristics of the Red Sea, current data can also provide insight into pressing topics such as the capacity of reef systems and benthic macrofaunal organisms to adapt to global climate change. Assessments of regional biodiversity and species distribution relative to their habitat will increasingly be required to inform science-based management approaches for the Saudi Arabian Red Sea, where environmental monitoring programs are still in their infancy.

## S4.15: Impact of climate and land use change on coastal ecosystem services and community resilience

**Sathaporn Monprapussorn**
Srinakharinwirot University

More than one third of the world's population lives in coastline area where ecosystem plays an important role in supporting many services. Ecosystem services are commonly divided into four categories: provisioning services, regulating services, cultural services and supporting services. Economies and livelihoods in coastal area depend heavily on the resources they provide, for survival and well-being. Change in the surroundings ecosystem in coastal area either temporal or spatial scale at which global climate change is occurring is one of the serious threats to coastal environment. Climate change and sea level rise tend to worsen coastal regions and thus lead to many impacts such as saltwater intrusion, habitat degradation and biodiversity loss. Land use change is one of drivers that will exacerbate climate change impacts by increasing vulnerability and reducing coastal resilience.
This study aims to discuss the additional and complicate role of land use on climate change in coastal region of Thailand and to develop analysis framework for the integration of climate and land use effect on coastal ecosystem services. Area of study consists of many tributaries networks which connecting the ecosystem of lands and seas make it as a suitable place for productive marine resources. Future climate projection reveals increasing trend in coastal flood

risk due to sea level rise and it could therefore impede the provisioning of fishery resources and decreasing in mangrove habitat. Land use projections were developed by using three scenarios based on different socioeconomic directions. Clue-S model was used to analyze possible area of different type of land use. Projected land use change results in urban expansion and aquaculture activities, while decreasing in agriculture and mangrove habitat. Climate and land use change have led to changes in ecosystem services. Policy makers must take land use into account when assessing climate change impact on ecosystem services. Coastal ecosystem resilient through effective adaptation framework could be of integral part to sustain healthy ecosystem in coastal area.

## S4.16: An Ocean Biogeographic Information System (OBIS) that supports GOOS and MBONs

**Ward Appeltans[1];** OBIS-ENV-DATA Consortium
[1] UNESCO

The Ocean Biogeographic Information System (OBIS) runs under the auspices of the Intergovernmental Oceanographic Commission of UNESCO, which is the international organization in the UN system, competent for marine scientific research, capacity development and transfer of marine technology, and was established in 1960 to promote international cooperation and to coordinate programmes in research, services and capacity building, in order to generate knowledge about the nature and resources of the ocean and coastal areas; and to apply that knowledge for the improvement of management, sustainable development, the protection of the marine environment, and the decision-making processes of its (now 148) Member States.
Under the International Oceanographic Data and Information Exchange programme of IOC, OBIS is in a process to develop and adopt a data standard that enables it to support the exchange of marine scientific research and monitoring data, which in addition to species occurrences often include environmental variables essential to understand the distribution of species and the effects of change. The standard allows for providing information on all facts and measurements of a sample, linked to an hierarchical structure of sampling events.
This new development is needed to respond to the requirements set by the Global Ocean Observing System (GOOS) to include biological and ecosystem variables and will support the Marine Biodiversity Observing Networks (MBONs).

## S4.17: Mapping Global Ecological Marine Units (EMUs)

**Roger Sayre[1];** Dawn Wright[2]; Sean Breyer[2]; Kevin Butler[2]; Keith VanGraafeiland[2]; Mark Costello[3]
[1] U.S. Geological Survey; [2] Esri; [3] University of Auckland

The U.S. Geological Survey, Esri, and a team of international marine scientists have mapped globally comprehensive, data-derived, true 3D, ecological marine units (EMUs) for use in global or regional scale conservation planning, impact assessment (climate, pollution, etc.), ecosystem accounting and valuation, research, and management. This first-of-its-kind assessment used NOAA's World Ocean Atlas data and advanced 3D clustering to delineate physically distinct vol umetric regions of the oceans based on temperature, salinity, dissolved oxygen, and nutrients. Preliminary results will be shown for the pelagic (water column) EMUs, and plans for delineating additional 2D EMUs on both the sea surface and sea floor will be discussed. The global EMUs are analogous to the terrestrial ecological land units (ELUs) recently produced in the focus on mapping environmental drivers which control species distributions. This work is a GEOSS Task from the Ecosystems Societal Benefit Area, and just as the ELU work was cross-listed with the GEO BON Working Group 3 (Terrestrial Ecosystems), the EMU work is an activity in the GEO BON Working Group 5 (Marine Ecosystems) work plan. Plans for data dissemination, access, exploration, analysis, and curation will be presented.

## S4.18: Towards a central world database on introduced marine species

**Mark Costello[1];** et al.
[1] University of Auckland

There are many online resources concerning introduced and invasive species. Some are of national or regional scope, others launched based on temporary project funding. In 2015, the World Register of Introduced Marine species (WRIMS) was established as part of the World Register of Marine Species (WoRMS). It is a contribution to GEO BON from the Marine Ecosystem Change Working Group. The species' taxonomy is fully integrated with WoRMS, and its editors can draw on the specialist knowledge of the taxonomic editors.
In establishing WRIMS numerous errors were found in online resources and the scientific literature with species being considered introduced or invasive with little to no evidence. These errors were perpetuated in other resources. Apart from resolving species identification, taxonomic, and terminology issues, maintaining a database on introduced species is complicated by the fact that their status varies geographically and over time, requiring near real time updates. This presentation argues that a centralised, geographically global in scope, expert-edited database is the most cost-efficient approach towards managing information and data on introduced species. It would need widespread support from the scientific and management community. This requires a permanent, open-access, professionally managed data infrastucture; formal recognition of the experts scholarly contributions; transparent governance and management of the intellectual property of the content and infrastructure; and long term financial support.

## S4.19: Bimodality of latitudinal gradients in marine species richness

**Chhaya Chaudhary[1];** Hanieh Saeedi Mark Costello[1]
[1] The University of Auckland

Unimodality is the most commonly reported latitudinal gradient, when species richness increases towards the lower latitudes and decreases toward the higher latitudes. It is assumed to be universal and often applied to marine species, even though the peak in some taxa was outside the tropics. However, a few studies reported the distribution as not unimodal and others as asymmetric. Some attributed a dip in the equator to sampling bias. Planktonic foraminifera and razor clams have been reported to have an asymmetric bimodal distribution, and marine mammals also peaked in the temperate zone with fewer species in the tropics.

Thus, three ecologically different taxa contradicted unimodality. In order to identify the general pattern in overall marine species, we compared the data from 14 published studies and 65,000 species from the Ocean Biogeographic Information System (OBIS), 2009. Contrary to our expectations, overall the 65,000 species and each of the other taxonomic groups, showed an asymmetric bimodality across latitudes, with a dip near the equator. However, despite the similarity in bimodality, the position of peaks in species richness differed between taxa. The equatorial dip was common to all the taxonomic groups assessed here and overall species, suggests it is not due to sampling bias. Our findings contradict the interpretation of many previous studies. This gives rise to a number of questions: Did the species have similar distributions in the past? Are they moving away from the equator due to climate change? Are the peaks different due to evolutionary factors or ecological interactions?

## S4.20: Challenges and solutions in modelling of marine benthic biodiversity in support of ecosystem management

**Elina A. Virtanen;** Markku Viitasalo[1]; Matti Sahla; Lasse Kurvinen; Ville Karvinen; Meri Koskelainen[1]
[1] Finnish Environment Institute (SYKE)

Present-day ecosystem-based management requires detailed information of ecological habitats and anthropogenic impact levels. Also, to protect and manage valuable habitats and ecosystems, it is necessary to assess the spatial variability of species distribution. Intensive field observation combined with modelling is usually the only way to gain such spatial information. Marine benthic ecosystems are difficult to assess and monitor, and this task is complicated by the limited number of applicable remote sensing products, which is usually the best way to get robust information of marine environment. Thus, it has been estimated that only 5–10 % of the seafloor is mapped at a comparable resolution to similar studies conducted on land.
The Finnish Inventory Programme for Marine Underwater Environment (VELMU) has surveyed systematically biodiversity and benthic habitats of the Finnish coast during 2004-2015. Underwater dives, videos, and fish larval inventories comprise ca. 120 000 sample points, not to mention thousands of invertebrate observations and geological acoustic surveys. The data is viewable in a recently opened map portal (paikkatieto.ymparisto.fi/velmu).
Because inventories can never cover every bay and lagoon, it is necessary to fill the spatial gaps by community and species level modelling. Bathymetry and seabed composition are essential predictors of bottom communities and remote sensing and multibeam echosounding are central in inventory programmes. In Finland, the turbidity of waters restricts the use of remote sensing products and the strict legislation prevents wide usage of multibeam echosounders. In addition, oceanographic models that provide information of e.g. salinity, temperature and stratification of water column are coarse in resolution and concentrated at the open sea, and therefore are not applicable to shallow and complex archipelagos of Finland.
We have developed alternative proxies to address aforementioned problematics with detailed fine-resolution spatial models and we have been successful in describing biodiversity, habitats and spatial variability of species off the coast of Finland. We suggest solutions for example to model topographic variation and hydrographic conditions, such as potentially anoxic bottoms and topographically sheltered sites with limited water exchange. We highlight the challenges of remote sensing and provide solutions to modelling the spatial variation of species and habitats

in the marine environment. We also discuss the usability of spatial models in assessing marine biodiversity and mapping of ecosystem services, and in making decisions on spatial conservation.

## S4.21: National Marine Sanctuaries as Sentinel Sites for a Demonstration Marine Biodiversity Observation Network (MBON)

**Frank Muller-Karger[1];** Francisco Chavez[2]; Steve Gittings[3]; Scott Doney[4]; Maria Kavanaugh[4]; Enrique Montes[1]; Mya Breitbart[1]; Katrin Iken[5]; Robert Miller[6]; Emmett Duffy[7]; Barbara Kirkpatrick[8]; David Anderson[8]; Mitchell Tartt[3]; David Obura[9]
[1] University of South Florida; [2] Monterey Bay Aquarium Research Institute; [3] NOAA National Ocean Service; [4] Woods Hole Oceanographic Institution; [5] University of Alaska Fairbanks; [6] University of California Santa Barbara; [7] Virginia Institute of Marine Sc

The U.S. Federal government (NOAA, NASA, BOEM, and the Smithsonian Institution), academic researchers, and private partners are implementing a Marine Biodiversity Observation Network (MBON). The goal is to monitor changes in marine biodiversity within a variety of geographic settings. The demonstration projects include four US National Marine Sanctuaries (NMS): Florida Keys, Monterey Bay, Flower Garden Banks, and Channel Islands. The Smithsonian is implementing several programs in the US and around the world under the Marine Global Earth Observatory (MarineGEO) partnership, directed by the Smithsonian's Tennenbaum Marine Observatories Network (TMON). The overarching goal is to observe and understand life, from microbes to whales, in different coastal and continental shelf habitats, and its role in maintaining resilient ecosystems. The specific objectives are to 1) Establish a protocol for MBON information to dynamically update status and trends reports; 2) Define an efficient set of observations required for implementing a useful MBON (this includes defining sets of Essential Ocean Variables useful to monitor biology and biodiversity); 3) Develop technology for biodiversity assessments including emerging environmental DNA (eDNA) and remote sensing to coordinate with classical sampling; 4) Integrate and synthesize information in coordination with other MBON projects, the Integrated Ocean Observing System (IOOS), the international Group on Earth Observations Biodiversity Observation Network (GEO BON), and the UNESCO-IOC Ocean Biogeographic Information System (OBIS); and 5) Understand the linkages between marine biodiversity, ecosystem processes, and the social-economic context of a region. Efforts are being made to engage with various countries in the Americas to participate in an MBON Pole to Pole in the Americas initiative proposed by Mexico. The present MBON pilot projects encompass a range of marine environments, including deep sea, continental shelves, and coastal habitats including estuaries, wetlands, and coral reefs. The program will use novel eDNA techniques and ongoing observations to evaluate diversity. Multidisciplinary remote sensing will be used to evaluate dynamic 'seascapes'. The MBON will facilitate and enable regional biodiversity assessments, and contributes to addressing several U.N. Sustainable Development Goals to conserve and sustainably use marine resources, and provide a means for countries to address targets and goals defined under the Convention on Biological Diversity.

## S4.22: Continental-scale assessment of indicators and biodiversity

## trends on Australia's rocky and coral reefs

**Amanda Bates[1];** Neville Barrett; Rick Stuart-Smith; Graham Edgar
[1] University of Southampton

Continental-scale assessment of indicators and biodiversity trends on Australia's rocky and coral reefs
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Systematic quality biological data are needed over broad scales of space and time to assess progress towards biodiversity targets. We use visual surveys by divers on Australian reefs from a global citizen science program, integrated with a scientific monitoring program, to illustrate a cost-effective mechanism for collecting quantitative data across multiple phyla and at high resolution. We use these data from rocky and coral reef habitats to inform indicators of ecosystem state in relation to the key pressures of fishing, ocean warming, invasive species, and describe the distribution of threatened species. Fishing impacts emerge as being wide-spread and pervasive, with warming-related community change at some locations. Invasive species are concentrated near harbours, while threatened species relatively common in the Great Australian Bight and Tasman Sea. Our approach offers a means of improved reporting against biodiversity targets to enhance public and policy-makers' understanding of marine biodiversity trends.

# Session 5: Biodiversity

## S5.1: A new flexible platform enabling broad-based, democratised data collection and aggregation for biodiversity and environmental monitoring

**Peter Brenton;** Stephanie von Gavel
CSIRO, Canberra

Data is the currency of monitoring – with the imperative to create big data sets over large geographic areas and a long period of time. This is particularly important to enable an informed (evidence based) response to increased human impact on the planet through global initiatives and strategies such as the Aichi Biodiversity Targets, the Convention on Biological Diversity (CBD), the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES), and others. Obtaining these "big data sets" in the spatial and temporal density required must involve mass data collection techniques and tap into sources of biodiversity data recording which have perhaps not previously been considered as legitimate or accessible sources. It must also involve large numbers of people.

Advances in internet and mobile technologies have enabled wider community participation in the collection of relevant data and reduced many of the data quality issues which have traditionally influenced scientific confidence in community generated data.
This presentation provides an overview of the Atlas of Living Australia's (ALA) data collection support capability and where it fits into the overall landscape of democratized biodiversity and environmental data collection in Australia.
The ALA is a large biodiversity data aggregation and access infrastructure which is funded by the Australian government under the National Collaborative Research Infrastructure Strategy (NCRIS). It is also a regional node of GBIF. The ALA develops and provides integrated, modular, open source platforms which support end-to-end biodiversity related data collection, aggregation, standardization and open data access for the science and research communities.
Tools such as BioCollect (http://biocollect.ala.org.au/) are now starting to capture and aggregate biodiversity related information from systematic scientific collection events, natural resource management interventions and citizen science activities and contributing significantly to the data holdings in the ALA which are aggregated from over 3200 data sets, and climbing!

## S5.2: Generalize the concept of EV to prioritize EO systems

**Joan Maso[1];** Hans Peter Plag[2]; Palma Blonda[3]; Ivette Serral[1]
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This communication reports on the findings in ConnectinGEO (H2020 project) workshop "Towards a sustainability process for GEOSS Essential Variables (EVs)" was held in Bari on June 11-12, 2015. The presentations and reports contributed by a wide range of communities provided important input from different sectors for assessing the status of the EV development. The workshop covered the status of EV discussions in agriculture, biodiversity, climate (and specifically atmospheric composition, carbon cycle, and greenhouse gasses), disasters, ecosystems, energy, health, water (and river discharge), and weather, and also in the thematic areas of citizen science, human settlements, oceans (and marine ecosystems), and solid Earth science (including volcanology).
From the analysis of the workshop presentations we distilled a definition of the essential variables that will guide the rest of the ConnectinGEO activities and the European Network of Earth Observation Networks (ENEON). EVs are "a minimal set of variables that determine the system's state and developments, are crucial for predicting system developments, and allow us to define metrics that measure the trajectory of the system". Specific application dependent characteristics such as minimum spatial and temporal resolution of observations and data quality thresholds are not included in the EV definition. In most societal benefit and thematic areas, the development of sets of EVs is a community processes leading to an agreement on what is essential for this goals of the community. While there are many differences across the communities in the details of the criteria, methodologies, and processes used to develop sets of EVs, there is also a considerable common core across the communities, particularly those with a more advanced discussion. There is some level of overlap between the EVs determined by different communities (e.g., Climate and Water), and there is a potential to develop an integrated set of EVs common to several or all societal benefit areas, which then could be complemented with specific EVs. In the need to define the priorities for setting up new observing systems or maintaining existing ones, the contribution to an EV can be taken into account as a factor that will increase the impact of it.

An observation that can contribute to more than one EV set needs to be prioritized even more. The impact criteria need to be balanced with the feasibility aspect to measure the EVs in terms of cost, effort, and impact playing a different role in different communities.
The societal development areas (SBAs) with a more mature development of EV are Climate, Ocean and Biodiversity. The Water domain is also maturing a set of EVs in GEOSS. There are also SBAs that are working with a common set of variables that can be considered essential for them. In that sense, agricultural monitoring is conducted both by the USA and EU in a similar way; Crop Area, Crop Type, Crop Condition, etc., are obvious candidates for Agriculture EV's. More work is required for an agreement on other EVs for this SBA. Ecosystems is a cross-domain area that can make use of existing sets of EVs (such as ECVs, EOVs and EBVs) complemented by socioeconomic variables that can help to define ecosystem services to human societies. Renewable energy can also make use of the ECVs but there is a need for additional variables. For example, solar surface irradiance and wind at different levels next to the ground are good candidates to explore. The Disaster SBA is one of the most heterogeneous areas dealing with catastrophes caused by a wide range of natural and anthropogenic hazards. Different sets of EVs are required fro the different hazards, the vulnerability of exposed assets, and the impacts of the hazards on communities. In particular, socioeconomic EVs are required to characterize vulnerability and resilience (e.g., demographics, availability of public services, productive infrastructures, etc.) and to measure the extent of the hazard impacts on human societies leading to disasters.
ConnectinGEO has focus on supporting Water, Agriculture, Renewable Energy and Ecosystems to make progress in the EV development by stimulating the debate in their respective international forums (mainly within GEO) using ENEON and GEOSS as catalysers of the process.

## S5.3: Abiotic characteristics have to be taken into account in ecosystem EBV

**Sébastien Barot[1];** Philippe Gros[2]
[1] IRD; [2] IFREMER

This talk presents the results of a workshop held in France and organized by the French ECOSOPE program and the Foundation for Research on Biodiversity. Our first conclusion is that defining EBV for ecosystems requires first determining what we want to do with the collected datasets and the related scientific issues. In our opinion 5 broad goals can be distinguished: (1) Ecosystem functioning must be studied, which requires monitoring various ecosystem variables to analyze how they covary and how they are linked to biodiversity (cf. EBV describing populations and communities). This requires monitoring the abiotic environment and properties emerging from the interactions between this environment and organisms. (2) It is of crucial importance to monitor and predict the impact of global changes (and particularly climate changes) on ecosystem functioning and the feedbacks of ecosystems to these global changes. (3) It is now fully recognized that human societies tightly depend on the functioning of ecosystems through the provision of the so-called ecosystem services (e.g. production of food). It is thus important to monitor these services. (4) Human societies impact ecosystems through most of their activities either impacting organisms or their abiotic environment. This means that it is important to monitor human activities at relevant scales to link ecosystem functioning, biodiversity and these activities. (5) Finally, it is important to predict from the present state and functioning of ecosys-

tems whether they are stable and will go on functioning similarly or whether they will endure drastic shifts.
From these general objectives it is possible to deduce the kind of variables we need to use as EBV for ecosystems. In particular, abiotic variables are crucial in this context. These variables are partially tackled outside GEO BON. Indeed, climatic variables are monitored within GCOS. Nevertheless, it seems important to measure such variables at temporal and spatial scales suitable to monitor ecosystems and populations. Moreover, many variables are abiotic but are tightly linked to the functioning of ecosystems and the organisms they host: they result from complex interactions between abiotic and biotic/ecological processes. We think they should be monitored within GEO BON. This is for example the case of many variables describing soils such as their pH, their structure, their content in organic matter, or organic nitrogen. This is also the case of variables describing water quality in marine or freshwater ecology (e.g. concentration in $CO_2$, dissolved organic matter, particulate organic matter). For the same type of reason, it seems to us important to document human pressures each time we monitor the functioning of an ecosystem. Taken together, we thus advocate for a very inclusive vision of EBVs addressing the ecosystem scale.

## S5.4: Integrating Drivers of Essential Biodiversity Variables Across Ecosystems

**Diana Bowler[1];** Laetitia Navarro[2]; Amanda Bates[3]
[1] Senckenberg Biodiversity and Climate Research Centre; [2] German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig; [3] National Oceanography Centre Southampton

A fundamental challenge in teasing apart the interacting effect of multiple drivers of change to explain biodiversity trends, including those of EBVs, is the mismatch in both space and time in the availability of data on physical, biological, and social variables. To start to address this challenge we collate the high quality global data layers that have direct interpretability with respect to most relevant drivers of change during the Anthropocene (i.e., climate change, extraction, habitat modification, pollution, and invasions). We first aggregate these drivers and data across terrestrial, freshwater, coastal and open-ocean ecosystems to facilitate cross-realm analyses. We compare these datasets in terms of their spatial and temporal scale (grain and extent) and highlight the gaps in data availability that presently limit our understanding of the processes driving biodiversity change. Second, we use our derived data layers to examine the spatial and temporal correlation among these drivers of biodiversity change. Third, we define biogeographic regions according to the impacts they experience and use our findings to identify regions of the globe that present unique natural laboratories for teasing apart the influence of different drivers on biodiversity change. Our over-arching goal is to improve the accessibility of driver data for cross-ecosystem comparisons of biodiversity change. We present this project to GEO BON as an opportunity to gain feedback from researchers and policymakers, with the objective to produce a useful resource for those working with EBVs and biodiversity change.

## S5.5: Identifying priorities for global monitoring of marine biology and ecosystems

**Patricia Miloslavich[1];** Nicholas Bax[2]; Samantha Simmons[3]; Ward Appeltans[4]; Albert Fischer[5]; John Gunn[1]; Melissa Andersen[6]; Frank Muller-Karger[7]; Raphael Kudela[8]; Sonia Batten[9]; Sanae Chiba[10]; David Checkley[11]; David Obura[12]; Emmett Duffy[13]; Lisandro Benedetti-Cecchi[14]; Yunne Shin[15]
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The Biology and Ecosystems Panel of GOOS aims to develop and coordinate a global monitoring program of Essential Ocean Variables (EOVs) that is globally relevant and driven by societal needs to facilitate scientifically based policy development and management on ocean and coastal resources.
EOVs must support management actions, comply with international conventions, and help predict how marine biodiversity and ecosystems will change in the future under increasing anthropogenic pressures. To identify biological and ecosystem EOVs the Panel followed a DPSIR process (Drivers-Pressures-State-Impact-Response). Societal drivers and pressures requiring sustained global ocean observations were identified by analyzing the goals and societal issues addressed by major international bodies/conventions, either binding or non-binding. Main drivers identified in these conventions were the need of: knowledge (science/data access), development (sustainable economic growth), conservation (biodiversity and ecosystems), sustainable use (biodiversity and resources), environmental quality (health), capacity building (technology transfer), food security, threat prevention and impact mitigation (to different pressures), management improvement (integrate ecosystem approach). The main pressures identified were climate change, ocean acidification, extreme weather events, overfishing/ overexploitation, pollution/ eutrophication, mining, solid wastes.
The current state of ocean observation of biological and ecosystem variables was assessed through an on-line survey to the major global and large-scale regional observing networks or programs informing on the extent in terms of geographic area, temporal scale, spatial scale, variables measured, availability and readiness of data that they are covering.
EOVs proposed through this process and also considering existing frameworks such as IMOS, IOOS, the PICO plan, SOOS, among others, are: phytoplankton biomass and productivity, incidence of Harmful Algal Blooms (HABs), zooplankton diversity, fish distribution and abundance, apex predator abundance and distribution, live coral cover, seagrass cover, mangrove cover, and macroalgal canopy cover. The variables identified with the highest level of readiness for implementation at a global scale where those related to zooplankton and coral reefs. The next step for the panel is to build specification sheets within GOOS standards and validate the proposed EOVs with the observing scientific community.

## S5.6: Can General Ecosystem Models be to Essential Biodiversity Variables what General Circulation Models have been to Essential Climate Variables?

**Michael Harfoot**
UNEP World Conservation Monitoring Centre

General circulation models (GCMs), which simulate the physics and chemistry of Earth's land, ocean and atmosphere, embody scientists' best understanding of how the climate system works and are crucial to making predictions and shaping policies. State-of-the-art GCMs have been shaped by and also have helped to shape earth observation and Essential Climate Variables, specifying where the greatest uncertainties exist in our knowledge of the Earth System, and what data we need most to improve our predictive abilities. The Essential Biodiversity Variables do not yet have an analogous interactive relationship with a holistic user community but we propose that general ecosystem models might fill that niche. We describe the Madingley General Ecosystem Model, the first model of the terrestrial biosphere that is generally applicable both on land and in the oceans, aiming to model all multicellular heterotrophic organisms. We discuss how the model could benefit from earth observation and how it might provide guidance on what data and information is most in need.

## S5.7: eLTER – european backbone infrastructure for integrated long-term ecosystem, critical zone and socio-ecological system research - aims and challenges of the scientific analyses of long-term ecological research

**Ingolf Kühn[1];** Michael Mirtl[2] and the eLTER ESFRI writing team
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Collective effort is needed to create the environmental research infrastructure for answering pressing questions in a world of rapid social, economic and environmental change. The overall purpose of eLTER is to provide a European distributed infrastructure of long-term research sites for multiple use in the fields of ecosystem, critical zone and socio-ecological research, and to secure highest quality interoperable services in close interaction with related European and global research infrastructures.
Ecosystem functions providing services relevant to society interact in extremely complex spatial patterns from local to global. The time scale of interactions ranges from microseconds up to phenomena driven by variations in Earth's orbit. Long-Term Ecological Research is a crucial component to disentangle processes and their drivers across the appropriate temporal scales in order to understand the planet or "earth system" in search of answers to the great challenges facing humanity like climate change, loss of biodiversity, eutrophication and pollution. Some key questions for managing and sustaining ecosystem services in the face of continuing global change are:

- How are ecosystems/biodiversity changing or adapting to global-change stresses?
- What are determinants of ecosystem resilience?
- What are threshold interactions resulting in system shifts?
- How can we respond locally, nationally and at international levels to support systems that are more resilient to global change effects?

Nevertheless, to make full use, it is important to implement an appropriate design, covering methodological, experimental, spatial, temporal and instrumentational aspects. In addition, complex analytical tools and procedures are necessary to take full advantage of the wealth of data resulting from such a concerted research infrastructure. Basic requirements and recommendation are given in the presentation.

## S5.8: The key role of metadata in Biodiversity Information networks: the EU BON experience

**Carlos Rodriguez[1];** Antonio García[2]; Juan Jose Negro[2]
[1] Estación Biológica Doñana EBD-CSIC; [2] Estación Biológica de Doñana - CSIC

The number of biodiversity information platforms have recently expanded as means to improve decision making processes through a linkage with envirionmental information. These platforms are expected to work as information hubs that facilitate the integration and use of information gathered from different sources. Such integration is being done by two different processes: using a common protocol to get the information and submit it to the platform's repository (e.g. Butterfly Monitoring Scheme), or mapping the information to determine the relationship between the data elements obtained from different sources and the data model used in the platform. This allows merging information from different sources and represent/analyse it jointly (e.g. GBIF). Metadata are crucial in this process and both proper metadata standards and controlled vocabularies should be used. The EU BON project from the European Union (Building the European Biodiversity Observation Network; FP7-ENV.2012.6.2-2) aims at delivering near-real-time data regarding biodiversity (both from on-ground observation and remote sensing) to the various stakeholders and end users ranging from local to global levels. Apart from other information sources, EU BON has their own biodiversity observatories that act as data providers, and test sites for tools and services developed in the project. In this talk, we will report on the metadata heterogeneity we found when dealing with information coming from these sites, how we integrated it, and we suggest changes regarding data acquisition, metadata creation and data sharing in order to improve their further integration in biodiversity information platforms.

## S5.9: Sharpening the resolution of biodiversity indicators transforms global picture of status and trends

**Simon Ferrier[1];** Tom Harwood; Andrew Hoskins; Kristen Williams; Chris Ware
[1] CSIRO

Two of the most widely employed indicators of global status and trends in terrestrial biodiversity are the proportion of land included in protected areas, and the proportion covered by relatively natural habitat. The spatial units against which these indicators are measured and reported – e.g. countries, ecoregions, major ecosystem types – are typically very large relative to the spatial grain of key environmental drivers shaping patterns of both biological distribution and land use. This mismatch of scales may limit the capacity of indicators to account for pervasive biases in the location of habitat loss and protection towards particular environments, and therefore particular biological elements, within reporting units. Here we show how this problem can be overcome by employing advances in big-data integration and macroecological modelling to combine the complementary strengths of recent developments in remote Earth observation and biodiversity informatics. We use over 300 million location records for more than 400,000 plant, invertebrate and vertebrate species to scale spatial turnover in biological composition (beta diversity) as a function of environmental and geographical position, for all terrestrial 1km grid-cells on the planet. Results generated by combining this modelling with high-resolution global data on protected-area boundaries and forest habitat change indicate that high covariance between spatial patterns of biological distribution and of habitat loss and protection at landscape scale significantly amplify potential consequences of habitat loss and inadequate protected-area coverage for biodiversity. This finding suggests that previous assessments based on proportional coverage of protected areas and natural habitats within relatively large reporting units have provided an overly optimistic perspective on biodiversity status globally.

## S5.10: Modelling intraspecific genetic diversity of freshwater biodiversity for conservation prioritisation

**Virgilio Hermoso[1];** Mark Kennard[2]
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The significance of evolutionary processes to maintaining current levels of genetic diversity and adaptive potential has long been as an important goal in conservation planning. However, rarely have conservation plans explicitly included information on genetic population structure in prioritising areas for conservation. The field of conservation genetics has experienced rapid progress in recent years, fostered largely by the development of more precise and affordable analytical techniques for exploring genetic structuring among populations. This might raise new opportunities to integrate genetic diversity and evolutionary processes into conservation planning approaches. Here, we demonstrate a new modelling technique, Generalised Dissimilarity Modelling (GDM) to model the spatial distribution of intraspecific genetic diversity of 4 freshwater fish species in the Daly River catchment (Norther Australia). We then incorporate the information in a conservation planning assessment to identify priority areas for the maintenance of genetic diversity. We contrast conservation plans based on traditional species distribution data, with those derived from intraspecific genetic data to assess the benefit of using spatially explicit estimates of genetic diversity in conservation assessments.
We found intraspecific genetic diversity could be adequately represented within priority areas identified using species distribution data, even at low conservation targets and for species with complex genetic structure. However, this was only true when using distribution data for the entire fish community. In contrast, a substantial portion of the genetic structure would not be represented in conservation priority areas by the distribution of the pool of species for which genetic data was available. These results should be contrasted elsewhere, but could have important implications for guiding the use of surrogates for genetic diversity in conservation planning at large spatial scales.

## S5.11: HydroATLAS: A global database of river and catchment attributes to facilitate aquatic ecosystem modelling and conservation planning

**Simon Linke;** Bernhard Lehner

Uptake of modern conservation planning methods is still hindered by two obstacles. These are a) defining the network topology that describes the connected nature of a river system and

b) the patchy data sources that often hamper conservation planning and add bias to data rich areas.
To facilitate broader application of modern species modelling and conservation planning methods, we designed a global database of river and catchment attributes. The data is derived from either existing or newly developed global datasets and is compiled in a hierarchical, nested breakdown of subcatchments. At the highest level of subdivision, the globe is split into over 1 million subcatchments.
For each of these subcatchments, we calculated a suite of local (within subcatchment) as well as upstream (entire watershed area) attributes for a variety of both natural and human influenced descriptors. These include variables of hydrology, inundation, groundwater, climate, terrain, soils, vegetation, topology, and network geometry. To characterise human disturbance, we summarised land use measures, including agricultural use, population and urbanisation, as well as socioeconomic data. Attribute layers and a suite of tools will be freely available in 2016.
In this presentation, I will give a brief overview about the HydroATLAS, but will also discuss example applications that are either already running or that are about to be started, such as a conservation plan for Papua New Guinea or a global examination of life history data.

## S5.12: The Biodiversity Intactness Index: modelling a global, fine-scale, annual indicator of terrestrial biodiversity to assess the biosphere integrity Planetary Boundary

**Andy Purvis[1];** Tim Newbold[2]; Adriana De Palma[1]; Andrew Hoskins[3]
[1] Natural History Museum; [2] University College London; [3] CSIRO, Canberra

The Biodiversity Intactness Index (BII) was first proposed in 2005 (Scholes & Biggs, Nature 434:45-49) as a broadly-based indicator of the state of ecological assemblages. BII reports the average abundance of a large, taxonomically and functionally diverse set of species in a region, relative to an unimpacted baseline. Because it reflects the functional diversity needed for healthy ecosystem performance, BII has been proposed as one of two metrics for assessing whether biodiversity loss has crossed the Planetary Boundary for biosphere integrity (Steffen et al., 2015, Science 347:736). However, data limitations mean BII has not previously been estimated globally or from direct analysis of biodiversity survey data. We have used the PREDICTS database – a global collation of data from published comparisons of assemblages facing different land use and related pressures, containing over 39000 species and 18000 sites – to model how local BII responds to land use, land-use intensity, human population density and proximity to roads. We then cross these model estimates with global, fine-scale, annual maps of these pressures (excepting roads, which are treated as static) to produce maps of BII for each year from 2001-2012. Our spatial projections suggest that biosphere integrity has fallen below the proposed Planetary Boundary across most of the Earth's surface – including where over 80% of people live. We map temporal trends in BII and highlight characteristics of nations associated with accelerating vs decelerating declines. We have produced BII estimates are available for each year for each country, IPBES subregion and IPBES region as well as globally, to facilitate their use in global assessments of biodiversity and ecosystem services.

## S5.13: Forest biodiversity and ecosystem services in the era of bio-based economy

**Mikko Mönkkönen;** Daniel Burgas; Tero Heinonen; Eric Le Tortorec; Maiju Peura; Tähti Pohjanmies; María Triviño
University of Jyväskylä

European and national strategies on bio-based economy aim at increasing use of renewable biological resources and their conversion into vital products and bio-energy. In forests this will result in more intensive management and increasing harvest rates. The Finnish national goal is to increase biomass extraction from forest by 30% from current levels by 2020. Here we analyse the effects of increasing biomass extraction on biodiversity and ecosystem services in Finnish forest landscapes in light of the Aichi 2020 targets. We simulated forest growth for a large production forest landscapes 100 years into the future under alternative management regimes and varied harvest intensity from the current level to a one-third increase in intensity. We estimated the effects of increased harvest intensity on biodiversity and ecosystem services by calculating the amount of suitable habitats for a set of indicator species (representing several social and conservation values) and the flow of selected ecosystem services (timber production, climate regulation through carbon sequestration, forest collectable goods). Our results show that achieving the targeted levels of forest biomass extraction from Finnish forests will likely result in a considerable loss in biodiversity and will also considerably reduce the flow of ecosystem services from the landscapes. The current level of biomass extraction for forestry and energy purposes is already a major threat for biodiversity, and compromises several valuable ecosystem services. We conclude that the national policy aiming at maximum economically sustainable biomass extraction will results in potentially large negative environmental and social impacts. Therefore, policies of a bio-based economy that would sustain biodiversity and multiple ecosystem services from boreal forest landscapes necessitate more balanced focus on alternative goods and benefits.

## S5.14: Climate Change Indicators to indicate Climate Change – Can we improve the Community Temperature Index?

**Diana Bowler;** Katrin Böhning-Gaese
Senckenberg Biodiversity and Climate Research Centre

Monitoring population response to climate change is an important challenge for ecologists. Generalized approaches that can be applied to population census data regardless of taxonomic groups are particularly useful as climate change indicators. Such indicators allow for standardized comparisons of how different taxonomic groups and communities in different locations are responding. As ambient temperatures increase, the relative performance of warm-adapted species is predicted to exceed the relative performance of cool-adapted ones. This community change can be summarized by the community temperature index (CTI), which is a community weighted mean of species' temperature niches. Already, "warming" or "thermophilization" of biological communities has been recognized as one of the main fingerprints of climate change. However, there has been growing recognition that interpretation of trends in the CTI is not straightforward. Species temperature niche often covaries with other species attributes, particularly habitat preference. For instance, forest bird species typically have cooler temperature niches than farmland and urban species. Because changes in land use are expected to lead to changes in the abundances of species according to their habitat preference, trends in the CTI could be influenced by land use change as well as climate change. We propose a novel model-based approach that separates temperature niche effects from other potential species attribute effects, such as habitat preference, on population abundance and allows calculation of the CTI that reflects only climate-change effects. We apply our approach to long-term population data of breeding birds in Denmark and demersal marine fish in the southeastern North Sea. Previous analysis indicates that abundance trends of European birds and North Sea fish are affected by climate change but in both cases additional factors are likely involved (agricultural intensification for birds; exploitation by fisheries for fish) and these factors may additionally affect the trends in the CTI. We compare the CTI trends with the original and our new CTI calculation to examine the consequences for the interpretation of species response to climate change. We also extend our analysis to examine the cause of any trends in the CTI, i.e., increases of warm-adapted species and/or declines of cool-adapted species, which is often omitted from CTI analysis despite helping to understand the mechanism and potential consequences of the community change.

## S5.15: Generating global condition surfaces for freshwater biodiversity to represent variables in the community composition EBV class

**Eren Turak[1];** Simon Linke[2]
[1] NSW Office of Environment and Heritage; [2] Griffith University

On-ground observations of freshwater biodiversity are biased and patchy with no data being available for any large area for any given point in time. This makes it difficult to determine change in biodiversity over time for comparing the status and trends in biodiversity among different regions. Spatially-continuous remotely-derived environmental layers can be used to model biodiversity patterns across regions to fill gaps with model-based inferences . Freshwater biological monitoring programs across the world have produced data and methods that can be readily used to develop regional or global models. Metrics representing taxonomic completeness of freshwater biological assemblages at a site are used extensively in assessing the condition of freshwater ecosystems .These metrics allow quantification of changes in local taxa richness (alpha diversity) resulting from anthropogenic stressors as a proportion of the potential number of taxa at a given location. The potential number of taxa is determined by setting ecosystem specific reference conditions. This may be done by sampling regional reference sites or obtaining this information from a variety of sources. Taxonomic completeness at un-sampled locations may then be predicted using remotely derived variables describing both natural variation and disturbance gradients. Spatially continuous disturbance layers that can be used for such modelling across large regions include fish habitat condition and general freshwater ecosystem disturbance at continental or Global scales. The global definition of hierarchically delineated watersheds (HydroBasins) provides a basis for aggregating the disturbance at larger watersheds to match the grain size of the models.
The assemblage level data collected in biological monitoring programs for freshwater can also be used to model compositional turnover (Beta diversity) across regions, continents or globally.

For terrestrial biodiversity, it has been shown that relationships between digital environmental layers (terrain climate and substrate) and compositional turnover can be determined at a global scale using available biodiversity observations and global terrestrial ecoregions. The delineation of Freshwater ecoregions of the world, the availability of freshwater specific disturbance layer and the capacity that HydroBASINS offers to apply stressor levels at desired grain size facilitates modelling compositional turnover in freshwater assemblages at regional continental and global scales.
Aggregating estimates of sub-catchment condition offer a practical, and therefore appealing, approach to global assessment in which there have been major advances. However, just as estimates of local species richness (alpha diversity) cannot simply be summed to estimate regional richness (gamma diversity) without knowing the degree of overlap in species composition between locations (beta diversity), sub-catchment condition cannot simply be averaged to estimate the regional state of freshwater biodiversity (i.e. the proportion of gamma diversity expected to be present in any given region). In regions that are well studied, beta diversity can be estimated as observed compositional dissimilarity among biological communities using species occurrence data. other regions inputs from methods such as species distribution models or habitat classification systems could also be used in assessing state of regional biodiversity it is desirable to account for the non-linear relationship between species richness and the area of intact habitat .
In this paper we present a modelling approach that uses data collected using existing monitoring protocols designed to represent community-level attributes of freshwater communities.. The approach integrates modelling steps into workflows allowing the potential for automating the generation of condition surfaces for indices based on community composition variables, from primary observations.

## S5.16: Indicators of broad-sense biodiversity: an overview of recent developments

**Andy Purvis**
Natural History Museum

Indicators of the current state of biodiversity have a vital role to play in regional and global assessments. Advances in ecosystem science have highlighted the importance of broad-sense biodiversity for resilient delivery of multiple ecosystem functions and services in changing environments. Although much recent indicator development has focused on benefits and responses – filling the biggest gaps in previous knowledge – a suite of new indicators of broad-sense biodiversity have also been developed by a range of teams worldwide. They range from observational through statistical models to mechanistic models; and produce EBVs ranging from population size through compositional intactness to direct estimates of measures of ecosystem function. I will give an overview of the new indicators identified and evaluated at a recent Future Earth workshop, outlining their strengths, limitations, similarities and differences.

## S5.17: Scaling essential variables, indicators and monitoring of biological invasion

**Melodie McGeoch;**
Monash University

Effective governance of the environment, including the problem of biological invasions, includes consideration of biological, analytical, reporting and jurisdictional scales. Local benefits accrue from awareness and adoption of global approaches by (1) being able to motivate for the importance of local initiatives in a global context, (2) aligning activities with best practice, and (3) being able to draw on readily available information resources. Globally, the benefits lie with accumulation of local tests of these schemes so that they can be refined where necessary. Importantly, harmonised approaches across scales facilitate rapid transfer of information and its translation into more targeted and relevant policy. Effective invasion management is supported by research, policy and management guidelines. However in practice there is often a disconnect between current, local scale information informing broader level policy, and also often a lag between international developments informing local scale action. In many cases global developments have lagged behind the varied local invasive species monitoring and information management solutions developed for specific applications. I will illustrate this with a selection of recent developments and examples in invasion science and policy in support of invasion monitoring and management. Keeping the pipeline of communication and information flow on biological invasions open across scales has multiple benefits. An approach to achieving this has recently been proposed and its further development and adoption is underway. This approach includes inter alia: (1) A small set of essential variables for invasion monitoring based on the concept of Essential Biodiversity Variables, and (2) a feasible, modular approach to the development of national (or finer scale) observation and monitoring systems for alien and invasive species. This approach will benefit efforts to slow the rate of biological invasions across local to regional and international scales.

## S5.18: Biodiversity, ecosystem services and human well-being: a selection of indicators for IPBES assessments

**Tuyeni Mwampamba[1];** Patricia Balvanera[1]; Dan Faith[2]; HyeJin Kim[3]; Alejandra Marques[4]; Berta Martin-Lopez[5]; Harini Nagendra[6]; Unai Pascual[7]; Fabian Scarano[8]; Suneetha Subramanian[9];
[1] National Autonomous University of Mexico; [2] The Australian Museum; [3] National Institute of Ecology; [4] Martin Luther University Halle-Wittenberg; [5] Leuphana University Lüneburg; [6] Azim Premji University; [7] Basque Foundation for Science,; [8] Federal Univer

IPBES' conceptual framework that guides IPBES global and regional assessments is composed of six interlinked elements that together define the socio-ecological system that humans depend on. While the natural science community has generated an immense body of knowledge on the state of biodiversity and ecosystems, how they change over time, and the natural and anthropogenic drivers of change, huge gaps exist in IPBES assessments in terms of identifying indicators for four of the six framework elements, specifically those that inform on the transformation of nature into benefits for humans, the subsequent contribution of those benefits to wellbeing, and the role of institutions, governments and anthropogenic assets in affecting benefits. These types of indicators speak to the very nature of the socio-ecological systems that will be subject to assessments and they require interdisciplinary teams to decipher and define them.

Focusing on these less explored elements of the IPBES conceptual framework and the flows between them, we describe here an approach that we developed to identify a list of viable indicators that could be used in regional and global assessments, and the outcomes of applying the process. We find that most of the indicators proposed are not included in neither the BIP, AHTEG or CBD sets of indicators. Applying a DPSIR approach, we find that there is a strong bias of indicators that express state and impact on benefits and wellbeing and fewer of those that inform on response of institutions and governments. Further work should try to balance indicators across the DPSIR categories, but it should also identify sets of indicators that tell a convincing narrative not only of the state and trajectory of services and human wellbeing, but of the socio-ecological system as a whole.

## S5.19: Use and availability of Ecosystem Services Variables in Sustainable Development Goals

**Ilse Geijzendorffer[1];** Emmanuelle Cohen-Shacham[2]; Anna Cord[3]; Wolfgang Cramer[4]; Carlos Guerra[5]; Berta Martin-Lopez[6]
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Multiple international policy objectives aim at ensuring future human wellbeing, the most recent effort being the Sustainable Development Goals. Even though the ecosystem services concept refers to a direct link between the benefits from nature and human wellbeing, indicators of ecosystem services are not necessarily used to evaluate the progress on human wellbeing targets. Our/This study identifies current inclusion of ecosystem services and related key variables, in international policy objectives and national reporting efforts. We used the ecosystem services variables as proposed in Geijzendorffer et al. (2015): “potential supply”, “supply”, “use”, “demand” and “interest”.
For this study, we identified which ecosystem services are mentioned in two key policy documents (the Sustainable Development Goals and the Aichi Targets) and the ecosystem variables proposed for the reporting phase. For the Aichi Targets, we compared these variable propositions with the indicators currently used for reporting. Additionally, we reviewed 258 indicators from seven national and one regional cross-sectoral ecosystem service assessments, to determine for which ecosystem variable they provided information.
Results:
1) Despite our expectations that the human-wellbeing SDGs policy objectives would likely focus more on the provisioning services, and that the biological diversity conservation objectives would likely focus more on regulating services and natural heritage, it seems all ecosystem categories are well covered by both policy documents. The top 25% of most cited services even form an equal distribution across all services categories.
2) When we consider the variables proposed to be included in the reporting, we do observe the expected patterns. Regarding the SDGs, more variables are proposed to capture demand and policies that should stimulate the interest in sustainable development, whereas the proposed list of indicators for the Aichi Target includes more variables on the potential supply and supply of ecosystem services.
3) The indicators used in ecosystem services assessments demonstrated an equal distribution over the provisioning and regulating ecosystem services categories (each 113 indicators), but the

cultural services were only represented by 11% of the indicators. The indicators for the cultural services seem relatively equally distributed over the variables, whereas the indicators for the provisioning services are biased towards the Potential supply, Supply and Use side of the ecosystem services flow. The indicators for regulating services show a reduced representation of the Supply and Use Variables. Only for very few services were indicators available for each of the variables. Recommendations:
With ongoing initiatives as IPBES and SDGs, there is a demand for ecosystem services indicators, which is currently not being met. Targeted efforts for specific services, but also specific variables is required to fill our current knowledge gaps. Without this information is it impossible to determine whether ecosystem services flows are going down due to an increase in demand, or due to degrading ecosystems and a reduced potential supply. In addition, this information allows for the identification of opposing trends between ecosystem services which are currently only implicitly included in the notion of "Sustainable Development" or "Essential Services".

## S5.20: Biodiversity and ecosystem services: What data does business need?

**Eugenie Regan;** Leon Bennun
The Biodiversity Consultancy

Businesses across a range of sectors now recognise biodiversity and ecosystem services (BES) as a material issue, posing regulatory and reputational risks and also opportunities. Businesses may need biodiversity and ecosystem services data to meet regulatory and financial requirements, to demonstrate good practice and, increasingly, for natural capital accounting. Specific areas where data are often needed include:
• Risk screening and identification of priority BES features;
• Assessing potential impacts;
• Avoiding, minimising, restoring and offsetting impacts;
• BES loss/gain forecasting and monitoring;
• Understanding and managing ecosystem service dependencies;
• Accounting for natural capital stocks and flows; and
• Meeting specific provisions of regulatory and financing safeguard frameworks.
Data needs for these may relate to species/ecosystem distribution, ecology and status (including past and predicted rates of change); location and status of sensitive sites and protected areas; habitat type and condition; ecosystem functions and services; land-use cover and change; and migratory pathways.
Although business may have very large BES impacts, there are limited data available to support these needs. IBAT for Business, the Global Ocean Data Viewer, global land cover datasets from ESA and USGS, and conservationevidence.com are some of the few data portals available for commercial use. Many other relevant data are not globally available or accessible. Businesses often have to compile or collect significant amounts of data for specific projects.
Priority areas for improving information provision include species Area of Occupancy maps, taxonomic coverage of Red List/KBAs, ecosystem threat assessment, Critical Habitat maps, reliable global land cover mapping, habitat type and condition maps, and finer-scale maps of ecosystem functions/services.
Many information gaps are owing to resource constraints in collecting, verifying, curating and

providing data. New resourcing models are needed to improve data and tools and allow elimination of paywalls, which can be a practical barrier to businesses using the best and most up-to-date information. Facilitating mechanisms would include strengthening of national BES databases and regulation to require sharing of environmental assessment data. Integrated regional land-use planning for development and BES conservation would reduce business data needs, minimise risks and improve conservation outcomes.
GEO BON has a key role to play in improving data availability and accessibility. The needs of end-users should be a consideration in the design of EBVs, BON in a Box, biodiversity monitoring schemes and online data portals. Businesses are key BES data users: providing them with the right data in the right format at the right time is a major opportunity to improve decisions impacting biodiversity and ecosystem services.

## S5.21: The Biodiversity Indicators Partnership - coordinating biodiversity indicator delivery

**Anna Chenery**
UNEP World Conservation Monitoring Centre

In 2010, the global community responded to the global crisis of biodiversity loss by adopting the Strategic Plan for Biodiversity 2011-2020. Tracking progress towards the goals of the plan using a suite of indicators allows the global community to focus responses on the most pressing issues. In September 2015, the Convention on Biological Diversity held an expert meeting (officially termed an ‘Ad Hoc Technical Expert Group (AHTEG)’ meeting) to review the global indicators available for the Strategic Plan for Biodiversity. One of the outcomes of the meeting was the development of a revised list indicators for the Aichi Biodiversity Targets.
The CBD-mandated Biodiversity Indicators Partnership (BIP) is a global initiative to promote the development and delivery of biodiversity indicators for use by the CBD and other biodiversity-related Conventions, for IPBES, for reporting on the Sustainable Development Goals, and for use by national and regional governments. The BIP brings together over fifty organizations working internationally on indicator development to provide the most comprehensive information on biodiversity trends. Recently, the BIP has worked to significantly support the 4th Edition of the Global Biodiversity Outlook (GBO-4) through the provision of global indicator information and the development of an indicator synthesis analysis which extrapolated global indicators to 2020 (Tittensor et al. 2014).
The BIP is currently working to enlarge and enhance its membership in light of the revised list of indicators for the Strategic Plan, including supporting the development of new indicators to fill gaps in the global framework. The BIP will also play a key role in supporting IPBES assessments at the global and regional levels.

# Session 6: Ecosystem Services

## S6.1: Essential Ecosystem Service Variables

**Patricia Balvanera[1];** Anna Cord; Fabrice deClerk; Evangelia Drakou; Ilse Geijzendorffer; Gary Geller; Daniel Karp; Berta Martin-Lopez; Tuyeni Mwampamba
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The exponential development of the ecosystem services field has led to a wide range of variables that have and can be measured. Yet, this wide array of information is often overwhelming: guidance is needed on which ecosystem service variables should be measured and monitored. To address this increasingly common challenge, over the last 2 years, the Ecosystem Services Working Group of Earth Observation-Biodiversity Observation Network (ES-GEOBON-WG6) has been developing a conceptual and methodological framework for identifying essential ecosystem service variables through several workshops and working groups. We have developed a pathway for identifying a viable set of ecosystem services that are essential, that practitioners should measure and track across space and time measure to gauge the state and changes in ES. In this presentation we propose a conceptual framework for the identification of ecosystem service variables as well as its application to a wide range of ecosystem services. While our approach builds from the experience of developing and using essential biodiversity variables (EBVs), it offers new insights into the challenges that emerge from the social-interactions that are at the core of ecosystem services.

## S6.2: Mapping ecosystem service values: a review of literature, a case study and future data needs.

**Jan Philipp Schägner;** Steven Peedel; Gregoire Dubois; Lucy Bastin; Mariagrazia Graziano; Bastian Bertzky; Andrew Cottam; Will Temperley

Mapping ecosystem services (ESS) values means valuing ecosystem services in monetary terms across a relatively large geographical area and showing how these values vary across space. Such maps are of great benefit for designing site-specific policies and institutions by high lighting trade-offs and synergies among different ESS that result from alternative development scenarios.
We reviewed all peer reviewed journal articles on mapping of ESS values and analyze and classify the applied methodologies regarding approaches to ESS quantification and valuation, ESS assessed, study rationale, reference to accuracy of the study results and case study area characteristics. Based on our findings we recommend a best-practice ESS value mapping approach, which uses separate statistical models to map the biophysical units of ESS supply and the value per unit of ESS supply. The approach is exemplified by a case study on recreational services. Nevertheless, we also acknowledge the difficulties in executing our proposed best-practice approach due to extensive data needs. Data is required for both: (1) as spatial predictor variables for modelling of ESS supply and its value and (2) and as real world observations / measurements of ESS supply and its values for model calibration and validation. One major aspect for improving data availability is data sharing of available data via online data repertories, such as the DOPA, ESP-VT and the BIOPAMA-RIS.

## S6.3: STRENGHTENING ECOSYSTEM SERVICES TOOLS FOR BON IN A

## BOX: A COLLABORATION OF WORKING GROUP 6

**Benis Nchine Egoh[1];** María Cecilia Londoño; Patricia Balvanera; Nicolas Urbina-Cardona; Gill Mike
[1] CSIR

The BON in a Box initiative seeks to provide common access to protocols, data management and analysis tools and software to map and monitor biodiversity to guide decision making at different spatial scales. GEO BON, Working Group 6 (WG6) brings together experts in Ecosystem Services from different institutions and countries with the aim to define protocols, frameworks and a set of indicators. The Beta version of BON in a Box provides an opportunity for WG6 to contribute tools for the evaluation, monitoring, analysis and reporting of ecosystem services. In this talk, we will present WG6 progress with regard to this goal. Both the content and the required steps will be presented. The steps taken in the collaboration between Working Group 6 and the BON in a BOX teams, are: (a) build a vision of why BON in a Box should include and recognize ecosystem services tools; (b) define the best structure for the tags by which to classify the ecosystem services tools; (c) recommend the best tools available to be integrated in a toolkit for ecosystem service monitoring; (d) collaborate to identify the best mechanisms by which working groups experts and other external ones (such as Ecosystem Services Partnership, ValuES (GIZ) initiative, Natural Capital Project, between others) can interact with BON in a Box users and maintain and update the tools. Finally we will emphasize on the importance of this tool for promoting common approaches to the monitoring and evaluation of Ecosystem Services and how this process can be adopted by the other GEO BON Working Groups to further develop and continually support a suite of biodiversity observation tools for BON in a Box. With the Ecosystem Services toolkit consolidated, we anticipate an improved and coordinated approach for the monitoring of changes in human well-being associated with ecosystem degradation, assessing the value, supply and delivery along global change scenarios to decision making and policy design.

## S6.4: Long-tem monitoring of biodiversity in tropical rain forests: understanding ecological determinants and human disturbance influences

**Miguel Martínez-Ramos**
Universidad Nacional Autónoma de México

Universidad Nacional Autónoma de México, Instituto de Investigaciones en Ecosistemas y Sustentabilidad. México
One of the major challenges of conserving tropical biodiversity is to understand the mechanisms that determine the coexistence of large numbers of species in relatively small areas in old-growth tropical rainforests. A growing number of hypotheses have proposed different ecological mechanisms to explain such coexistence. This study explores some of these hypotheses using study systems located in two Mexican tropical rainforest reserves. In the Montes Azules Biosphere reserve (ca. 400, 000) I established a set of 14 permanent plots (0.5 ha each) distributed across four environmental units contrasting in topography and soil. In these plots, between

1994 and 2016, annual survival, growth and recruitment rates were monitored for more than 220 species found in a sample of more than 4,000 trees with DBH of 10 cm or more. Over 22 years, about 35% and 9% of the original number of trees and species were replaced. For more than 100 species it was possible to obtain mortality, recruitment and population growth rates. Demographic rates of low abundant (rare) species were subject to stochastic temporal (inter-annual rainfall variation) fluctuations while those of most abundant species were regulated by density dependent mechanisms. The magnitude of such stochastic and deterministic effects varied across environmental units. In the Los Tuxtlas Tropical Field Station (700 ha) we monitored the population dynamics of the understory palm Astrocaryum mexicanum for 40 years (1975-2013), and documented how the lost of density dependent regulation mechanisms, due to human disturbances, have resulted in a demographical explosion of this palm that was followed by a reduction in tree species diversity in the forest. We use the two study cases to emphasize the importance of on site long-term biodiversity monitoring and maintain biotic interactions in reserves in order to ensure biodiversity conservation.

## S6.5: "Essential Ecosystem Variables" emerge from linking Essential Climate and Biodiversity Variables

**Talie Musavi[1];** Miguel D. Mahecha; Mathias Disney; David Frank; Martin Herold; Mirco Migliavacca; Jens-Christian Svenning; Gaia Vaglio; Laurin Flurin Babst; Aletta Bonn; Joachim Denzler; Karl-Heinz Erb; Fabian Gans; Victor H. Gutierrez-Velez; Martin Jung; Jens Kattge; Signe Normand Da
[1] Max Planck Institute for Biogeochemistry

The concepts of "Essential Climate Variables" (ECVs) and "Essential Biodiversity Variables" (EBVs) were developed by two different communities to efficiently monitor the changing climate system and ongoing threats to biodiversity. Yet these two are sometimes dependent on each other and also partly constrained by processes happening at the ecosystem scale. By focusing on the interactions and relations among ECVs and EBVs, we may enhance our capacity to monitor the interconnected climate-biosphere feedback system. In this contribution we scrutinize a wide range of these coupling processes relying on the ECV and EBV concepts which leads us to a series of emerging "Essential Ecosystem Variables'" (EEV). We show that an explicit consideration of EEVs can provide insights on ecosystem functioning and allow us to monitor, understand and forecast climate-biosphere interactions in a changing environment. We call for a broad consultation among the relevant science communities to derive EEVs, shape upcoming integrated monitoring strategies, and most generally to (re)vitalize movement towards an "Essential Planetary Variable" framework.

## S6.6: Contribution of Earth Observation for deriving soil information in the biodiversity context

**Uta Heiden[1];** Derek Rogge[1]; Andreas Schmitt[1]; Martin Bachmann[1]; Anita Bayer[2]
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One of the focal areas in the discussion of Essential Biodiversity Variables are Ecosystem services that comprise provision of food, fibres, clean water and clean air, just to name a few. The basis required for such ecosystem services depend among other factors on soils (Turbé et al, 2010). The importance of soils has been realized by several communities, most importantly by experts working in the field of agriculture and food security. 2015 has been declared as the International Year of Soils by the Food and Agriculture Organization of the United Nations (FAO) underlining the importance of the ecosystem functions of soils.

The remote sensing community can provide information about the status and evolution of soils. As an example, soil moisture is one of the abiotic factors affecting and impacting the soil biodiversity. Soil moisture directly affects the dielectric properties of target “soil”. The simple law “the higher the moisture, the higher the dielectricity” leads to a stronger backscatter in the microwave spectrum. Special radiometer missions like SMAP (Soil Moisture Active Passive) and SMOS (Soil Moisture and Ocean Salinity) measure this response in order to derive the moisture content (Adams et al., 2015). These missions provide soil moisture estimations every 3-5 days on a global basis.

Additional contributing parameters are soil structure and texture, soil salinity and pH value of soils, all regulating the micro-, meso- and macro fauna of soils. Soil structure geometrically takes place in the range of a few centimeters, which is the range of the microwave spectrum used for Synthetic Aperture Radar sensors. The special range projection of this sensor type even increases its sensitivity for surface characteristics. Numerous studies already showed that the brightness values of the backscattering as well as polarimetric parameters are directly linked to surface roughness (Marzahn and Ludwig, 2009). With the new Sentinel-1 mission of the European Space Agency the temporal resolution of C-band SAR acquisitions will rapidly increase to about one image per week until the end of this year. Therefore, extremely dense time series will be available in the foreseeable future in order to compensate the remaining deficiencies.

Parameters such as soil texture are since many years in the focus of the optical and thermal remote sensing community. Soil texture classes distinguish the particle-size distribution of soils naming the relative proportions of sand, silt and clay. Various studies using hyperspectral data have been carried out to determine the quantitative abundance of minerals that determine the texture of soils (e.g. Chabrillat et al, 2002, Bayer et al., 2012). Further, hyperspectral data contain sufficient spectral information to quantify other important mineral groups such as iron bearing minerals that impact the pH-value, texture and structure of soils (Bayer et al., 2012).

Soil organic carbon (SOC) impacts the physical properties of the soil. Here, the soil color is often used estimate SOC that can be measured with different accuracies depending on the sensor systems. Hyperspectral data provide a much finer spatial resolution in the VNIR wavelength region enabling to consider the shape of the reflectance curve. Moreover, spectral indicators in the SWIR region can be used to identify and quantify carbon constituents such as lignin and cellulose. However, also multispectral sensors can be used. Especially the European Sentinel-2 sensor system is appropriate due to the very small spectral bands in the VNIR that allows for soil color estimation.

However, observations of soil constituents using optical, thermal as well as SAR data is often hampered by the coverage of soils by permanent (forests) and temporary vegetation (crops) or artificial surfaces such as in urban areas. Further, depending on the ecosystem, the sensed reflectance signal is intermixed with other land cover types such as dry and green vegetation depending on the spatial resolution of the Earth Observation systems. Due to the wide and free availability of multispectral Earth Observation data, new multitemporal techniques are currently under development to maximize the data source for soil related remote sensing analyses. Examples are given for a mid-European area where exposed soils are rather rare. In a semiarid area of South Africa, unmixing techniques (Rogge et al, 2012) have been developed to reduce the

influence of vegetation on the mixed pixel signal.
The presentation gives a rough overview about the current drawbacks and opportunities of providing soil information using Earth Observation and present selective techniques under development that are focused on large scale soil information retrieval to provide a basis for further EBV discussion.

Anne Turbé, Arianna De Toni, Patricia Benito, Patrick Lavelle, Perrine Lavelle, Nuria Ruiz, Wim H., Van der Putten, Eric Labouze, and Shailendra Mudgal. Soil biodiversity: functions, threats and tools for policy makers. Bio Intelligence Service, IRD, and NIOO, Report for European Commission (DG Environment), 2010.
FAO, retrieved from http://www.fao.org/soils-portal/soil-biodiversity/en/

## S6.7: Lessons learnt from existing Essential Variables and the way forward for Ecosystem Services

**Perrine LAROCHE[1];** Evangelia Drakou
[1] UBO

Proposed for the first time in the 1990s by the Global Climate Observing System, the concept of "Essential Variable" (EV) led to calls for systematic observation of a selected set of critical variables. Since then, the international scientific community has proposed a set of essential thematic variables for climate (ECV), biodiversity (EBV), the ocean (EOV), and many more, intended to improve the monitoring of nature's elements and to help detect on time extreme incidents. Entering the Anthropocene era, the need for considering the human element has emerged and hence, the need to generate EVs for Ecosystem Services (EESVs).
To support this initiative, we did an analytical study on "lessons learnt" from the existing EVs, we considered how ecosystem services are different from the other EV thematics and sought to suggest basic principles to be considered when proposing EESVs.
For this purpose, we reviewed the scientific (peer-reviewed and grey) literature on EVs in order to identify: the context under which different types of existing EVs have been created; their basic characteristics; the political and scientific context under which each has been defined as "essential"; and their current or potential use. From each publication we extracted information on: applied conceptual frameworks, criteria of selection, scalability of EVs, units of measurement, end-users (if applicable). In most cases, there was no explicitly defined framework applied. We then used the existing knowledge on EVs and Ecosystem Services (ES) to provide guidance for proposing Essential Variables for Ecosystem Services. We used the "lessons learnt" from our review and our knowledge on the ES concept to propose criteria to be considered for defining Essential Ecosystem Services Variables (EESVs).

## S6.8: Measuring ecosystem services variables in Mediterranean wetlands

**Ilse Geijzendorffer[1];** Brigitte Poulin[2] Anis Guelmami[2] Patrick Grillas[2]
[1] IMBE & Tour du Valat; [2] Tour du Valat

The Mediterranean Basin has been predicted to be one of the most vulnerable places for ecosys-

tem services provision in the future. In addition, wetlands in the Mediterranean climate suffer the most under anthropogenic pressures and simultaneously provide many regulating ecosystem services. For many of the services provided by wetlands, information is unevenly distributed or absent on specific Ecosystem services variables (i.e. “potential supply”, “supply”, “use”, “demand” and “interest” following Geijzendorffer et al. 2015).
In this presentation, we demonstrate for the network of wetland observation sites around the Mediterranean Sea, which ecosystem services are included in existing policy objectives, which monitoring data is currently available for these services and their variables.
Results:
A large selection of ecosystem services are included across the objectives in Ramsar, Aichi targets and the Sustainable Development Goals. Certain key objectives for ecosystem services (e.g. Aichi Target 14), however, tend to be very vague, which renders implementation of monitoring and reporting difficult. RAMSAR includes only few services and no provisioning services (not even fresh water), whereas the Aichi targets and the SDGs both contain provisioning and regulating services in roughly equal proportions. The monitoring of trends between ecosystems services is not included anywhere, although they could reveal important trade-offs (e.g. between provisioning versus regulating services). To determine the impact of multiple anthropogenic pressures and whether sustainable development is taking place, explicit information on trade-offs is urgently needed.
In comparison to the indicators that are proposed for monitoring and reporting, the Aichi reporting is even more strongly biased towards monitoring of potential supply. Monitoring of biodiversity and ecosystem services in wetlands around the Mediterranean are strongly limited by data availability, but the Mediterranean Wetlands Outlook (2012) actually offers more indicators on a more diverse range of variables than proposed by RAMSAR.
Ways forward
To improve estimates for the Ecosystem Services Variable “Potential supply”, we advance our understanding on the ecological functioning of ecosystems, via EO –based approaches to obtain more accurate maps of land cover and surface water dynamics. To improve the spatial and temporal resolution of information on wetland habitats extent, agricultural use and denaturalization, we work on the use of Sentinel images in two European projects, SWOS and ECOPOTENTIAL. Developed land cover correspondence tables with nomenclatures used in MAES, Corinne Land Cover and the RAMSAR improve the interoperability of our local data with international reporting.
To get a better estimation of how ecosystem services are co-supplied through human interventions (Ecosystem Services Variable Supply), we have developed Mar-O-Sel, a model which permits to distinguish natural (rainfall) from artificial water inputs and their respective contribution for maintaining wetland integrity under different climate for the whole Mediterranean Basin.
Recommendations
We are making progress on our capability and coherency of monitoring of ecological change and ecosystem services in Mediterranean wetlands, but more information is needed on the different aspects of ecosystem services flows and trade-offs between ecosystem services to be able to guide sustainable development and human well-being towards the future. For this a combination of field surveys, more optimal use of remote sensing information and integration with demographic/societal information is needed.

## S6.9: Mapping cultural marine ecosystem services from space: fact or fiction?

**Evangelia Drakou[1];** Linwood Pendleton
[1] University of Brest

The increasing availability of high-resolution satellite images is making it possible to measure and observe the different ecosystem components, fact that has improved the way we can monitor biodiversity. But humans are part of nature too and research is also focusing now on understanding the human-nature interactions and the ecosystem changes associated to it. Although methods and techniques to detect that keep advancing in the land, in the ocean we still have room for improvement.
In this work, we explore the possibility of using remote sensing to assess and map marine ecosystem services through a case study. Our major questions are two: what remote sensing data is available and what do we still need to improve in terms of data collected from space?
We selected the Pelagos sanctuary of marine mammals as a test case. Pelagos is a large (~90 000km2) transboundary Marine Protected Area (MPA) within the Mediterranean Large Marine Ecosystem (LME) between France, Italy and Monaco. It is an area with intense touristic activity where whale-watching tourism and recreational boating take place. Our basic assumption is that marine mammals, like whales and dolphins can be detected from space. Testing this, we want to assess the cultural ES of the Pelagos sanctuary that are related to these marine mammals and map the areas where they mostly occur. This approach is a first of test cases within the Mediterranean basis. This approach will be applied and tested in more areas within the Mediterranean LME, under the framework of ECOPOTENTIAL H2020 project.

## S6.10: The extent of edge effects in fragmented landscapes: Insights from satellite measurements of tree cover

**Mateus Dantas de Paula;** Jürgen Groeneveld; Andreas Huth
Helmholtz Centre for Environmental Research - UFZ

Due to deforestation, intact tropical forest areas are increasingly transformed into a mixture of remaining forest patches and human modified areas. These forest fragments suffer from edge effects, which cause changes in ecological and ecosystem processes, undermining habitat quality and the offer of ecosystem services. Even though detailed and long term studies were developed on the topic of edge effects at local scale, understanding edge effect characteristics in fragmented forests on larger scales and finding indicators for its impact is crucial for predicting habitat loss and developing management options. Here we evaluate the spatial and temporal dimensions of edge effects in large areas using remote sensing. First we executed a neighborhood pixel analysis in 11 LANDSAT Tree Cover (LTC) scenes (180 x 185 km each, 8 in the tropics and 3 in temperate forested areas) using tree cover as an indicator of habitat quality and in relation to edge distance. Second, we executed a temporal analysis of LTC in a smaller area in the Brazilian Amazon forest where one larger forest fragment (25,890 hectares) became completely fragmented in 5 years. Our results show that for all 11 scenes pixel neighborhood variation of LTC is much higher in the vicinity of forest edges, becoming lower towards the forest interior. This analysis suggests a maximum distance for edge effects and can indicate the location of unaffected core areas. However, LTC patterns in relation to fragment edge distance vary according to the analyzed region, and maximum edge distance may differ according to local conditions. Our temporal analysis illustrates the change in tree cover patterns after 5 years of fragmentation, becoming on average lower close to the edge (between 50 and 100 meters). Although it is still unclear which are the main causes of LTC edge variability within and between regions, LANDSAT Tree Cover could be used as an accessible and efficient discriminator of edge and interior forest habitats in fragmented landscapes, and become invaluable for deriving qualitative spatial and temporal information of ecological and ecosystem processes.

## S6.11: Mapping pollination types with remote sensing

**Daniel Doktor[1];** Hannes Feilhauer[2]; Sebastian Schmidtlein[3]; Andrew Skidmore[4]
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Remote sensing is increasingly used to map and monitor functional plant traits. In particular optical leaf properties such as chlorophyll content, specific leaf area, or structural traits like mesophyll thickness that are responsible for the optical signal are frequently targeted. In contrast, the remote sensing potential to map pollination as an ecosystem service - by targeting flowering and pollination traits - has not been exploited yet. Here, we aim to address the following questions for an extensively used mosaic of grasslands and mires in Bavaria, Germany: (1) Is the distribution of pollination types in the study site related to optical traits that account for a characteristic spectral signature? (2) Can we map spatial patterns of pollination types with high resolution remote sensing data?
To address the above, cover fractions of all occurring vascular plant species and traits related to their spectral signal were sampled in 100 plots randomly distributed across the study site. The BIOLFLOR trait data base was applied to extract information on pollination vectors and selfing abilities of the occurring species. Furthermore, we employed remotely sensed airborne hyperspectral imagery (AISA Dual, Specim) of the study site. Machine learning methods (support vector regression) were used to link the plot pollination data to the canopy spectra from the airborne hyperspectra campaign. The model results show that the spectral signal can explain up to 55% of pollination data variation with an Error $<$ 10.5%. In particular patterns of wind and insect pollination are closely linked to traits determining canopy reflectance properties and can thus be accurately addressed with spectral data. Model application onto the remotely sensed imagery allows for spatially explicit predictions that can be used to map the distribution of pollination types across the study area. These maps may enable additional analyses that provide new insights towards a better understanding of ecosystem functional diversity. The results of this study show that relations between optical and pollination traits exist and enable a detailed and accurate mapping of the ecosystem service pollination.

## S6.12: Ecosystem service mapping using imaging spectroscopy: Applications in land management and conservation

**Daniela Braun;** Alexander Damm Michael E. Schaepman
University of Zurich

Environmental change severely impacts the functioning of ecosystems and the supply of ecosystem services (ES). Monitoring approaches are urgently needed to estimate consequences for

human well being, to improve knowledge of underlying feedback mechanisms, and to facilitate the definition of management strategies and policy making. In this context, mapping ES provides relevant information for decision-making in land management and conservation. However, this knowledge is limited due to a lack of continuous and detailed ES maps.
Remote sensing opens new opportunities to overcome this problem. We demonstrate the capability of remotely sensed data to map ES by following strictly causality between observations, ecosystem functions, and ES. We investigated a heterogeneous landscape west of Zurich (Switzerland), covering a land cover gradient ranging from semi-natural ecosystems to urban areas. Airborne imaging spectroscopy data were used to measure sun-induced chlorophyll fluorescence and subsequently estimate gross primary production (GPP). Two GPP-related ES – climate regulation and food supply – were quantified using mechanistic models.
We demonstrate the application of both ES maps for land management and conservation: Resulting ES maps allow quantitative assessments of ES supply across a landscape and identified hot and cold spots of ES supply provide additional decision factors for land management and conservation. Furthermore, we discuss the relationship of food supply and climate regulation with functional biodiversity and can confirm existing theory of a typical diversity-function dependency.
We conclude on the usefulness of remote sensing for ES mapping by applying the still theoretical concept of ES as a practical tool for environmental assessments and decision-making in land management and conservation.

## S6.13: No ecosystem service left behind: rediscovering the biodiversity basis of ecosystem services

**Silvia Ceausu**

The concept of ecosystem services was first proposed in the context of conservation as a way to raise awareness of the social and economic implications of biodiversity. However, science encountered big challenges in describing the relationship between biodiversity and ecosystem services. As a consequence, most of our models of ecosystem services left out biodiversity and have relied on biophysical data such as land-use or elevation maps. Here, we are reconnecting ecosystem services with one aspect of biodiversity - species richness. We map the richness of species supplying 9 ecosystem services in Europe: three provisioning, three regulating and three cultural services. The taxa considered in our analysis are plants, birds, mammals and herptiles and we used the atlas data available for these taxa at a resolution of 50X50 km. We compare our results with maps of ecosystem services based on biophysical data and we show that leaving out biodiversity from the assessment of ecosystem services leads to an incomplete picture of ecosystem services supply. We also discuss the need to research the relationship between different ecosystem services and biodiversity. Assuming the supply of ecosystem services as a function of species richness, different function shapes lead to drastically different results. Therefore, we call for further empirical research and synthesis on the relationship between aspects of biodiversity and ecosystem services.

## S6.14: The role of MODIS in national-level assessment of Ecosystem

## Services

**Alessandro Gimona;** Laura Poggio; Andrea Baggio; Marie Castellazzi
The James Hutton Institute

We illustrate the contribution of MODIS data to a national scale (Scotland ) assessment of key ecosystem services (ESS) at 1 km resolution. We describe methods to combine and assimilate multiple data sources with MODIS data. In particular new statistical approaches used to assimilate image time series, and the role of MODIS in upscaling input data sets for ESS models and in understanding biodiversity patterns at the national scale.
We show that MODIS is a very useful source of data for assessment over large areas, contributing to the quantification of ESS. We finally illustrate how MODIS can be included in a workflow that leads to a transdisciplinary assessment of risk for the provision of ESS based on spatialised Bayesian networks.

## S6.15: Bayesian modelling of ecosystem services using Earth Observation: A prototype for avalanche protection

**Ana Stritih;** Adrienne Grêt-Regamey
ETH Zürich

Mountain ecosystems provide a broad range of ecosystem services such as climate regulation, protection from natural hazards, tourism, and habitat services. The provision of these services is increasingly jeopardized by climate change, natural disturbances, and land use change. The assessment of ecosystem services, the trade-offs between them, and their potential future development in a spatially explicit way is an important tool for decision makers in conservation, ecosystem management, and spatial planning. Earth Observation is a promising source of data for such assessments, as it provides spatially explicit, area-wide, and timely data on ecosystem characteristics, even in areas where in-situ data is scarce. However, the links between ecosystem properties and services, as well as their response to change scenarios are subject to many uncertainties. To make the ecosystem services concept operational in practice, there is a need for integrated modelling approaches that make these uncertainties explicit and facilitate interaction with stakeholders.
Bayesian networks are a powerful tool to describe complex socio-ecological systems and incorporate the related uncertainties. Their graphical representation facilitates communication with stakeholders, they can incorporate local knowledge, and can be iteratively updated as soon as new evidence is available. As part of the EU H2020 project ECOPOTENTIAL, a modelling approach that integrates EO-based assessments of ecosystem services, their valuation, and scenarios of change in Bayesian networks is being developed in a set of focal regions. Here, we present an example of a Bayesian network for avalanche protection, a crucial ecosystem service provided by forests in mountain areas such as the alpine region of Davos.
Protection forests can prevent avalanche releases, or detain snow during an avalanche and decrease impact pressures. The protective function depends on the forest structure (species composition, density, and vertical structure), which are derived from LiDAR and optical images. Based on terrain models and forest characteristics, avalanche run-out distances and impact pressures are predicted using the RAMMS numeric model. We assess the demand for avalanche

protection based on the locations and types of potentially endangered buildings. The potential cost of damage caused by avalanches is used as a proxy for the value of the protection service. By extending the network to include other ecosystem services (e.g. carbon sequestration, habitat, and cultural services), we will be able to identify potential trade-offs or synergies between them. In managing a set of ecosystem services, decision-makers should take into account the considerable uncertainties in the quantification of the services and their provision under scenarios of future change, which are made spatially explicit in our approach.

## S6.16: Modelling Water Yield using InVEST: Lessons Learned in US and UK

**Guy Ziv[1];** P. James Dennedy-Frank[2]; John Redhead[3]; Rebecca Logsdon Muenichb[4]; Indrajeet Chaubeyb[4]; Charlie Stratford[3]; Katrina Sharps[3]; Laurence Jones[3]; Tom Oliver[3]; James Bullock[3]
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Hydrologic ecosystem services, such as provisioning of water for municipal, industrial and agricultural use, are beginning to influence land management decisions through both regulations and investments targeted at protecting and improving water resources. There is great need for simple decision support tools, in particular spatially explicit models that can estimate water yield and the impact of land use change on the availability of water resources. One such tool is the Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) annual water yield model, developed by the Natural Capital Project. The InVEST annual water yield model uses a Budyko curve approach to estimate actual evapotranspiration, subtracting that from precipitation to predict available water at an annual timescale. In this talk, I will discuss two studies aimed at validating this model. First, I will compare InVEST to a “gold standard” hydrological model (SWAT) at two distinct sites in the US: the Wildcat Creek Watershed in Indiana and the Upper Upatoi Creek Watershed in Georgia. The InVEST and SWAT models provide similar estimates of the spatial distribution of water yield in Wildcat Creek, but very different estimates of the spatial distribution of water yield in Upper Upatoi Creek. Thus, the InVEST model may do a poor job estimating the spatial distribution of water yield in some area, probably where storage dynamics is important. Secondly, the same model was used to simulate the annual water yield in 22 UK catchments with widely varying land cover, population and geology and tested using both global-scale and UK-scale data sets against gauged river flow data from the National River Flow Archive. Using UK-scale input data (UKCP09 and MORECS), the model performed well, with model output closely following the trend in observations, however using freely available global-scale datasets (WorldClim and Global-PET) it resulted in much poorer agreement with measured values. Together, both studies suggests cautious is needed when using simple hydrological ecosystem models such as the InVEST annual water yield model, and calls for improving meteorological data and performing validation against observational data.

## S6.17: Influence of temporal scale on ecosystem services supply and interactions in Southern Chile

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Ecosystem functions and services interact in different ways, intensities and on different spatio-temporal scales across the landscape. Mapping ecosystem services at different scales supports the aggregation of complex information to i) quantify the interaction among them, and ii) to provide scale-specific information for planning and management on different levels. Therefore the understanding of how several ecosystems services interact among each other and between different land use types is crucial to maximize multiple services to strengthen landscape resilience and sustainable management. Higher temporal resolution can support the observation and integration of heterogeneity in the ecosystem services research, improving the assessment of human impacts on ecosystems over time. The study is based on Landsat time series analysis to identify the trajectory of ecosystems changes from 1985 to 2011 at a regional scale. The study area is located in the northern Chilean Patagonia which is a hotspot area of biodiversity. The land cover information is integrated with biophysical data using a spatial explicit model (InVEST). Provisioning (forest plantation production), regulating (carbon storage, soil protection, P retention) and cultural (aesthetic value) ecosystem services were quantified and analyzed. This mapping is the base for following spatial correlations among several services and the analysis of their changes over time. The result shows that using higher temporal resolution data allows an improved understanding of the interactions (trade-offs and synergies) misinterpretations that can happen by ignoring ecosystem service history and change over the time. The research explores the limitations and opportunities of integrating the historical dimension in ecosystem services analysis and its implication for management.

## S6.18: Linking Ecosystem Services demand and supply on indigenous hunter-gatherers communities of the Chaco Salteño forests (Argentina)

**Maria Vallejos[1];** Domingo Alcaraz Segura[1]; Javier Cabello[2]; José María Paruelo[3]
[1] Universidad de Granada; [2] Universidad de Almería; [3] Universidad de Buenos Aires

Land use changes in the Chaco Ecoregion are taking place in dry forests historically inhabited by indigenous people. Traditionally, these communities have been devoted to collecting and hunting as livelihood, depending on the Ecosystem Services (ES) provided locally. The intensification of agricultural expansion over the last 15 years is affecting their wellbeing and deepening socio-environmental conflicts. The objective of this study is to evaluate the loss of local ES caused by deforestation and forest degradation in 202 indigenous communities of the eastern Salta province (Argentina). For this purpose, we first estimated the loss of forest area used by the communities to satisfy the demand of final ES (food and materials). Second, to estimate the loss in the intermediate ES supply in this area we analyzed the trends in productivity, fires frequency and climate regulation using earth observation techniques. The estimation of the forest usage area to satisfy the demand of ES by the communities was based on previous participatory mapping where the community members draw the distances travelled for food collection and hunting. To estimate the loss of intermediate ES supply in the remaining usage area, we evaluated the temporal trends in variables derived from remote sensing related to productivity (MOD13Q1-EVI), fires (FIRMS data) and climate regulation (CHIRPS data) from 2001 to 2015. We reported that the usage area have been reduced by 18% in relation to the area of forest demand. We detected significant negative trends in variables related to productivity at 64% of the communities. Obtaining quantifiable measures about the loss of effective territory used by the communities, changes ecosystem functioning and degradation becomes useful to support indigenous rights in legal causes associated with land tenure, and it has specific applications

for territorial planning.

## S6.19: Mapping ecosystem services and tree diversity of urban gardens in the City of Leipzig using a hybrid remote sensing approach

**Roland Kraemer[1];** Ellen Banzhaf[2]; Ines Cabral[3]; Anna Cord[2]; Jessica Keim[3]; Florian Wolf[4]; Helen Kollai[1]; Aletta Bonn[5]
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Urban gardens constitute a considerable resource for ecosystem services and biodiversity in cities. The City of Leipzig has a long-lasting tradition of allotment gardening initiated by the Schreber movement in the late 19th century leading to one of the highest ratios of urban garden areas among European cities (2.8% of the city area and 16 $m^2$ per citizen). We derived estimations for ecosystem services and tree diversity of urban gardens in Leipzig using a hybrid mapping approach based on multiple remote sensing data sets, such as digital orthophotos (DOP), a digital terrain model, and very-high resolution multispectral images acquired by an unmanned aerial vehicle (UAV). For image processing we used object based image analysis (OBIA) and different indices (e.g., LAI, sNDVI). The remote sensing part was supported by detailed field surveys. Further, we analyzed inter-functional relationships of the urban gardens with surrounding structure types (brownfields, differentiated residential areas) through GIS analyses incorporating detailed land-cover and environmental data in order to assess climate regulation and air purification effects (e.g., cooling corridors, wind and dust mitigation) within the entire City of Leipzig. 3D-models, combined with the field surveys, were used to assess the vegetation structure, including tree diversity. An important share of our research is to provide spatial information on essential biodiversity variables (EBV), such as community composition and ecosystem structure. We could show that a hybrid use of DOPs and digital terrain models is highly profitable for the classification of a large variety of vegetation types (trees, shrubs, grassland). By the aid of the UAV we could develop a parameter to adjust vegetation and biomass estimations previously based solely on DOPs and to enhance our knowledge on EBV. We found that urban gardens represent an important urban structure type for providing ecosystem services and tree diversity, thus supporting to the quality of life in urban areas and enhancing environmental conditions. Our work is a contribution to monitor urban green infrastructure at fine resolution, which is crucial to achieve sustainable and resilient cities, also in the light of climate change mitigation and adaptation.

# Session 7: National BONs and tools for BON development

## S7.1: Monitoring networks for habitats and species in Flanders

**Toon Westa[1];** Geert De Knijf[1]; Patrik Oosterlynck[1]; Floris Vanderhaeghe; Paul Quataert[1]; Marc Pollet
[1] INBO

Information is needed on the conservation status of habitats and species in order to support nature policy in Flanders and to report to the European Commission in the framework of the Habitat and Bird Directive. The Research Institute for Nature and Forest (INBO) is responsible for developing and implementing monitoring networks to provide this information.
Two monitoring strategies are used to fill in information needs for Natura 2000 habitats: (1) habitat mapping within Special Areas of Conservation to assess the distribution and area of habitats and (2) a regional network of permanent sample plots to assess habitat quality. Monitoring has started in 2014. We use a 12 year monitoring cycle, which means that every year approximately 1/12th of the area is mapped and 1/12th of the samples are measured. Data collection is performed by professionals at INBO and the Agency of Nature and Forests (ANB).
We follow two complementary approaches to fill in information needs for species: (1) standardized monitoring networks for a set of priority species (both Natura 2000 species and species of regional importance), and (2) analysis of unstandardized data using site-occupancy models. Standardized monitoring networks provide the best guarantee to obtain unbiased results but are quite expensive. Implementing these monitoring networks is only possible if we can rely on volunteers for data collection. Therefore we aimed at achieving a pragmatic design that both provides the necessary information and guarantees sufficient participation of volunteers. In 2016 we start with the implementation with the new monitoring networks. Data collection by volunteers is coordinated by an NGO (Natuurpunt).
Currently INBO is also developing a set of monitoring networks for abiotic conditions (soil, surface water, groundwater and atmospheric deposition) to support nature policy and to explain trends in conservation status of habitats and species. At the moment a detailed analysis of information needs is being performed.

## S7.2: Promoting the Effectiveness of Network Activities of Terrestrial Observation of Biodiversity, Ecosystems, and Ecosystem Services

**Eun-Shik Kim**
Kookmin University

Presentation is made to discuss in promoting the effectiveness of network activities of terrestrial observation of Biodiversity, Ecosystems, and Ecosystem Services (BEES). Issues on the reorientation of the assessment of the current status of biodiversity conservation and/or utilization are discussed including the issues for overcoming the ambiguousness and addressing the gaps in defining the current status and the ultimate goals for the conservation and/or utilization of biodiversity at regional and global levels. In addition, issues on securing the strategies and the framework for the promotion of the observation of BEES are suggested in terms of refining context, goals, and gaps in observation to establish the effectiveness of the observation on regional and/or global levels. Furthermore, the issues of governance on the structure, function, and development of the networks are discussed in evaluating the effectiveness of the networks at different levels. Key components for promoting the network activities of biodiversity observation are suggested in terms of outputs and outcomes (e.g., services to societies), inputs and processes (e.g., standardized protocols for observation), and strategic planning in governance, finance, and infrastructure as the three pillars of importance. Limitations of the current network activities are discussed in terms of heightening the Zeitgeist in overcoming the problems and the failure in securing the conservation on top priority in the public awareness based upon the urgency of the issue in the Era of the Sixth Extinction. Discussion is further extended in promoting the networks of terrestrial observation of BEES in evaluating current status, identifying the threats and their consequences in short- and long-term perspectives, suggesting the measures against the degradation of biodiversity and ecosystems, and securing the framework to deal with the issues, effectively.

## S7.3: AP BON since 2008: its achievements and challenges

**Tetsukazu Yahara[1];** Eun-Shik Kim[2]; Sheila Vergara[3]
[1] Kyushu University; [2] Kookmin University; [3] ASEAN Center for Biodiversity

Responding to the call of the first GEO BON conference in 2008, the first workshop of AP BON (Asia Pacific Biodiversity Observation Network) was held in July 2009 in Nagoya to develop a network of biodiversity scientists in the Asia-Pacific region. Since then, AP BON have been developed through many meetings including the most recent 7th workshop held in Bagkok in February 2016, under the support of MOEJ (the Ministry of Environment Japan). In 2010, AP BON contributed to the success of CBD COP 10. From 2011 to 2015, a project called S9 (Integrative Observations and Assessments of Asian Biodiversity) sponsored by MOEJ had been promoted as a core-project of AP-BON in which more than 100 Japanese scinentists and many collaborators of Korea, China, Vietnam, Lao, Cambodia, Thailand, Malaysia, Indonesia and the Phillipines had been participated in. In AP-BON and the S9 project, we carried out 7 categories of activities including (1) recording states, (2) mapping states, (3) detect changes, (4) assessing risks, (5) prioritizing actions, (6) publishing together and (7) networking observation sites, persons, institutes and data. Parts of activities, achievements and findings of AP BON and the S9 project have been published in more than 100 papers of refereed journals and also in two volumes of AP BON Books in 2012 and 2014 from Springer. The observation activities include (1) plant diversity assessments in SE Asia, (2) describing tree trait diversity in tropical forest, (3) development of genetic diversity monitorings, (4) fish diversity assessments in Mekon river basin, (5) selection of candidate EBSA in AP and (6) assessment of coral distribution predicted under climate change and ocean acidification. In addition to those activities, AP BON contributed to coordinate networks of some well-organized biodiversity observation activities in Korea, China, Taiwan and India and activities of ACB (ASEAN Center for Biodiversity). Database structure and data sharing system have been developed in ABCD net directed by China, ACB as a clearing house of CBD, TaiBIF in Taiwan and S9 in Japan. AP BON also contributed to coordinate networks of international and regional organizations including GBIF, IUCN, ILTER-EAP, GEOSS-AP and ESABII. While AP BON has been successfully developed, it faces with some challenges. Because participants in AP BON have exceeded 100 and are still increasing, it is now required to establish a better governance of AP BON including membership management, publication of newsletters, and continued updates of the website. Based on the successful networking to date, in the next step, we need a stronger, collaborative secretariat mechanism to support the growing activities of AP BON.

## S7.4: The Atlas of Living Australia – A modular biodiversity information platform with global implementations

**David Martin**[1]; Peter Brenton[2]; Stephanie von Gavel[2]
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The Atlas of Living Australia (ALA) has been developed as a national open source platform which first went live in 2010. The modular architecture of the ALA enables customisation for other country and region level portals, with several international developer workshops having been run with support from GBIF to facilitate this process. It has enabled the ALA to begin building an open source community around the ALA software.
There are now production installations of the ALA in Brazil, Spain, France and the UK, as well as developments in Portugal, Argentina and other countries. There are also several thematic hubs of the ALA operating within Australia as well as some independent websites and mobile apps using ALA web services to GET data from the ALA and POST data back.
This presentation will outline the current components and architecture of the ALA and demonstrate the flexibility of its application and deployment for varying communities of interest and purpose.
The ALA is a large biodiversity data aggregation and access infrastructure which is funded by the Australian government under the National Collaborative Research Infrastructure Strategy (NCRIS). The ALA develops and provides integrated, modular, open source platforms which support end-to-end biodiversity related data collection, aggregation, standardisation and open data access for the science and research communities, as well as the general community, business and government to support the digital transformation in the sharing of biodiversity knowledge.

## S7.5: Atlas of Living France: GBIF France's portal - access to primary data about biodiversity provided by French institutions

**Marie-Elise Lecoq**[1]; Fabien Caviere[1]; Anne-Sophie Archambeau[1]; Régine Vignes Lebbe[2]; Sophie Pamerlon[1]; Eric Chenin[3]
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There are now over 600 million records available through the GBIF (Global Biodiversity Information Facility). These records represent the contribution from data providers linked to the nodes of GBIF.
National portals can provide a tailored view for a country, allowing a node to bring together region specific information (attribution, species lists and traits, spatial layers) to further enhance the basic occurrence information. They also provide an important mechanism to galvanise data mobilisation efforts within a country.
The Atlas of Living Australia (ALA) provides a framework for such national needs, which also connects with GBIF. The ALA team supports a technical community that helps to install and configure the modules of the ALA platform. Moreover, developers all across the world can also contribute to it by developing new functionality to give back to the community.

GBIF France (http://www.gbif.fr) launched its new portal based on ALA at the end of May 2015. The next step on our roadmap will be the installation and the configuration of the advanced spatial component of the ALA platform. These new features will be launched the 10th of June 2016. We have been able to customise this generic infrastructure to our local needs (e.g., links to different GBIF French partners) and requests (e.g., adding a map to the result page), styling the portal so that it can be integrated into our national website, translating it into French and integrating pre-existing components developed by the French team.
We have also begun to submit projects in order to help others French speaking countries to install and configure their own data portal using ALA modules. This type of project will help the community around ALA to be further developed around the world.
In this presentation, we will present the GBIF France's data portal and its spatial portal. We will also describe the human aspect of the project by presenting the community created around ALA and how reusing an existing software can be motivating and stimulating. Then, we will conclude with the future objectives for our national portals and the different possibilities for the GBIF France's IT Team to help the community.

## S7.6: „Living Atlas - Nature Germany“ – synthesizing volunteer conservation and biodiversity observation initiatives in Germany

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Biodiversity observation and conservation initiatives in Germany are borne by volunteer work. However, data collection and storage on the variety of taxa and spatial coverage is organized by different learned societies, NGOs, national and local authorities, museums of natural history, universities and other scientific institutions. Many of these institutions collect and maintain their data by the aid of Citizen Science projects, which often operate only on a local scale. Moreover, each project follows its own survey design, taxonomic concept, data standards and host its own database, not necessarily digital or accessible through a web portal. Following the urgent need for a more comprehensive approach we are currently carrying out a feasibility study for a Living Atlas of Germany that aims to bring together the multiple projects and data sources in one online portal to synthesize biodiversity monitoring and conservation efforts in Germany. We develop a framework for such a portal in dialogue with representatives of all relevant institutions, through workshops, questionnaires, meta analyses and personal conversations. At this, the first and foremost objective of the atlas platform is to build up a network of cross-taxonomic experts, conservation organizations, scientists, authorities and citizens to enhance communication, coordination and knowledge exchange. Additionally, consensus is that the atlas initiative should harmonize existing heterogeneous survey and data standards and provide services, such as hosting databases, providing web space or developing analysis tools or applications, especially for smaller and/or ill-equipped projects. An upcoming Living Atlas of Germany is also considered to serve as a tool for environmental education and to preserve taxonomic knowledge. In a progressed phase the portal is supposed to include supportive abiotic data, such as climate and environmental data, land cover/use, and also socio-economic parameters to facilitate an added value through professional and meaningful cross-component analyses.

# S7.7: From regional to national and international biodiversity networks - data of the Flora of Bavaria initiative free for use

**Tanja Weibulat[1];** Wolfgang Ahlmer[1]; Marcel Ruff[2]; Iris Leininger[1]; Markus Weiss[1]; Stefan Seifert[1]; Andreas Plank[1]; Andreas Fleischmann[3]; Dagmar Triebel[1]
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The data networking project 'Flora of Bavaria' (http://www.bayernflora.de) started three years ago. It has the ambitious goal to organise and mobilise recent and historical digital data records from a number of hitherto independently curated data sets as well as from analogue data collections. The data are those of former plant monitoring projects in Bavaria mainly done in German grid system with varying granularity as well as from currently running ones. In addition, data from herbaria and literature sources are addressed and a Bavarian taxonomic reference list is curated.
Beside the data management team in Munich, about 100 persons are directly or indirectly involved, some 50 of them as active volunteer monitoring experts. The working group 'Arbeitsgemeinschaft Flora von Bayern' acts as a coordinating group for these people. The data is managed in the relational database management system Diversity Workbench (DWB; www.diversityworkbench.net) with installations at a recognized research data repository (see Re3data citation). The data processing and long-term archiving is done according the standards of the Open Archival Information System (OAIS) and new content standards set up in the context of the project German Federation for Biological Data (GFBio). A special focus is to establish new user-friendly workflows from individual data storage systems to the central databases to guarantee the mobilisation of occurrence data also in the future. Major project partners are from the recognized regional botanical societies, the Bavarian Environment Agency , the Bavarian universities and the Staatliche Naturwissenschaftliche Sammlungen Bayerns.
The Bayernflora data portal, mainly known as Botanischer Informationsknoten Bayern (BIB; www.bayernflora.de -> 'Karten & Steckbriefe', in German) is online since 2003. It has several search options for taxa and was originally developed together with users involved in regional biodiversity research, geobotany, phytogeography, vegetation sciences and nature conservation projects. Detailed information on a number of occurrence and taxon-assigned biodiversity variables, traits and categorizations like red list status together with high quality images is delivered. Now around 5 million occurrence data in German grid system of the topographical maps at 1:25.000 (quadrants) or calculated to receive equivalent accuracy are provided. In parallel, a subset of 2.7 million with core information for free use is delivered via two national and international biodiversity networks: GFBio (www.gfbio.org) and Global Biodiversity Information Facility (GBIF; www.gbif.org). A cooperation with data exchange between the FloraWeb portal (http://www.floraweb.de/) and the Bayernflora initiative has just started. All services are described in the Bayernflora Wiki.
This semantic Bayernflora Wiki is actively designed (more than 480 pages now), augmented with freely available domain-specific information and used by people of all generations interested in nature observation. These might be citizen scientists as well as trained plant experts from various nature conservation agencies and biologists from various disciplines. The Wiki platform includes a quiz to learn more about medical plants and a forum for the identification of plants. All information and data is presented free for use according to various types of creative common

licences.
With the advanced organisation of high-level structured data, the Flora of Bavaria initiative is able to fulfill community specific platform standards as well as international data exchange standards. The project is going to evaluate concepts to manage the publishing of a traditional flora in a printed version together with the online publishing of continuously changing scientific content. A concept addressing the whole data life cycle with focus on long-term storing, archiving and providing occurrence and observation data for nature conservation and environmental management purposes is set up. This includes new approaches to meet the criteria of an open data community and to link open data by providing a stable taxonomic backbone via web services (see Ahlmer 2016 onwards).

## S7.8: Contribution of Citizen Science towards Global Biodiversity Monitoring

**Eren Turak**
NSW Office of Environment and Heritage

To meet collective obligations toward biodiversity conservation and monitoring, it is essential that the world’s governments and nongovernmental organizations tap all possible sources of data and information, including new, fast-growing sources such as citizen science (CS), in which volunteers participate in some or all aspects of scientific projects. Our review assesses where CS and community-based monitoring (CBM, a subset of citizen science) contributions are currently most significant and where opportunities for growth exist. We use the essential biodiversity variable (EBV) framework to describe the range of biodiversity data needed to track progress towards global biodiversity targets. Existing CS and CBM data describe a number of EBVs including species distribution and population abundance, species traits such as phenology, and ecosystem function variables including primary and secondary productivity. A few taxa and variables (e.g. occurrence and phenology of birds, butterflies and plants) are extensively monitored at scale while other taxa garner strong regional interest. Some regions (e.g. Europe, North America, South Africa, India, Australia) have better geographical coverage than others . We identify three areas where investments could substantially enhance the use of CS data to help achieve international biodiversity monitoring and conservation goals. First, we (the biodiversity monitoring community) must expand the breadth of EBVs, taxa, and geographical locations monitored via CS. Second we must scale up and integrate local efforts, and take other measures to help them to contribute to standardized data repositories such as the Global Biodiversity Information Facility (GBIF). Third we must make better use of existing CS data and maximize synergies with Earth observation and modelling. Many of these investments and actions are in early stages of development or implementation.

## S7.9: Modelling species distributions with citizen science data - benefits and limitations

**Patricia Tiago;** César Capinha; Henrique M. Pereira

Conservation biology and biodiversity monitoring programs can greatly benefit from citizen science initiatives. In particular, species occurrence records by citizen scientists could allow filling

information gaps on species geographical ranges once the number of citizen science projects collecting opportunistic records of species occurrences are increasing throughout the world. However, there are concerns about data reliability and temporal and spatial biases.
In this work, we address the question of whether species records in opportunistic citizen science projects can improve existing knowledge on species geographical ranges. This is done by comparing the observed climatic niche using data from an opportunistic citizen science project in Portugal (www.biodiversity4all.org) and a scientific data set having the same area and taxonomic coverage. The climatic niche of each species for the two data sources was delimited by means of a convex-hull enclosing the species occurrences in a standardized bi-dimensional climate space. We calculated the percentage of the climatic niche width of the scientific Atlas that was captured by the opportunistic citizen science data. We also collected a set of variables plausibly explaining the differences found. The percentage of the climatic niche that was captured differed markedly among species. About one third of the species had more than 50% of its known climate niche captured by BioDiversity4All data. Generalized linear mixed models relating explanatory variables and variation in the percentage of climatic niche captured by the opportunistic data revealed that species with wider distribution ranges and making use of forest habitats were better surveyed opportunistically.
We conclude that data collected in citizen science opportunistic projects can provide valuable data for the understanding of species environmental requirements, ultimately aiding in the determination of their geographical ranges. However, the comprehensiveness of the data collection is strongly taxa dependent. We identified a few species-related factors associated with a better/worst opportunistic sampling.

## S7.10: How long-term biodiversity monitoring benefits from the involvement of paraecologists

**Ute Schmiedel**
Universität Hamburg

Paraecologists and parataxonomists, professionals with local knowledge, being largely trained on the job in one or more fields of ecological science (Schmiedel et al. 2016, www.paraecologist.org), may play an important role in supporting applied ecological research. They support the time-consuming fieldwork to assess biodiversity. Paraecologists and parataxonomists can have a broad portfolio of tasks: collection, processing of specimens, rearing, data basing, photographing, writing, teaching, mentoring, guiding visitors, conducting expeditions, maintaining vehicles or scientific equipment, biodiversity monitoring, support of all types of research of social and natural scientists in the field of ecosystem service assessment, and facilitating communication between scientists and communities. While the focus of parataxonomists lays more on the collection and processing of specimens of (mainly invertebrate) taxa that are unknown to science, paraecologists are often also involved in ecological research in the broader sense, including biodiversity monitoring.
The involvement of paraecologists into long-term biodiversity monitoring revealed to be of high value for the working process. They help to find rare and well-hidden species and to assess the abundance values per species and plot. But even more important is their role in facilitating the communication between land users and scientists. As a member of the local rural community that uses the rangelands where the monitoring is conducted, paraecologists help to share the

objectives of the research and the land-user relevant monitoring results with the land users as well as share the land users' concerns and questions regarding the research activities with scientists. The paraecologists' involvement thus not only helps to speed up the work but also improve the working relationship with the custodians of the land.
Based on more than 10 years of own experience with paraecologist programmes (e.g., www.biota-africa.org; future-okavango.org) and the exchange with related programmes (Schmiedel et al. 2016), I will present the role of paraecologists in biodiversity monitoring. The talk will reflect on the experienced benefits and challenges of the paraecologist approach and related capacity development activities. Based on these experiences the way forward towards the mainstreaming of the paraecologist approach for in-situ biodiversity monitoring will be discussed.

## S7.11: how citizen science can contribute to a national BON: the French experience

**Romain Julliard**
Muséum national d'Histoire naturelle

To a large extent, biodiversity monitoring depends on Citizen Science and thus, its success on the easiness to implement such schemes at a national scale. Certainly this depends partly on deeply rooted socio-cultural characteristic of each country. Overall, it is quite obvious that citizen science is much more widespread in the Anglo-Saxon cultural area than in Latin countries. Let us see how monitoring biodiversity through citizen science has been implemented in France. France typically has small national NGOs. For example, the Bird Life representative LPO (Ligue de Protection des Oiseaux) has about 40,000 members, which is, proportionally to the national population size, 50 times less than the RSPB in the UK. This reflects the little willingness of French to get engaged in collective projects. This also means that NGOs alone are not able to launch ambitious national monitoring initiatives. There was thus room for another national actor to lead monitoring schemes. It turned to be the National Museum of Natural History. This was favored by the particularity of this Museum to hold a fairly large research department with more than 400 researchers, part of them being devoted to Ecology. In addition, this research institution is under the joint authority of the Ministry of Research and the Ministry of Environment. Documenting the state of biodiversity is thus part of its duty.
A key issue for launching such large scale, long term project is to be legitimate (which here meant building legitimacy). Monitoring started as often with birds, and benefit from the fact that the Museum holds the French bird ringing scheme. Ringing schemes are indeed likely the oldest "modern" citizen science scheme, where modernity reflects the intricate partnership between academic researchers and non-researcher citizen. In 1989, the Museum launch simultaneously a classical Breeding Bird Survey (BBS) based on point counts and a "Constant Effort Site", its counterpart based on Capture-recapture by amateur ringers. Both were part of the same program entitled "STOC" which translate into Temporal Survey of Common Birds. Two aspects facilitate launching: one was coupling BBS to ringing for which the Museum has already the legitimacy; the other was to focus in the title on common birds, thus avoiding overlap with atlas project which are concerned by all species (and thus proportionally much more by rare species). It is only in 2004 that the first significant scientific paper came out from the STOC program (Julliard et al 2004). But this was the start of a considerable expansion of monitoring programs. One factor was the concomitant emergence of biodiversity indicator based on Mean Species Abundance capitalizing on Breeding Bird Survey and other monitoring schemes, ensuring considerable po-

litical interest for these schemes. This was also the time when citizen science started to become fashionable, as a tool to reconnect people to nature.

## S7.12: Participants' motivations in a citizen science project: a Portuguese case-study

**Patricia Tiago;** Henrique M. Pereira; Maria João Gouveia

Citizen Science, as the general public involvement in scientific research activities, has recently become a mainstream approach to collect data for many different scientific studies. Researchers realized that citizens involved directly in their research rapidly increased their scientific literacy and interest in science. Citizen science has been thus recognized not only as a methodological tool for a given research experiment, but also as an education and outreach tool for researchers. Yet, participation levels on citizen science studies are very different across countries and projects; existing little information about what determines citizen's participation and motivation. Here, we wanted to understand citizens' intrinsic motivation (IM) to participate on a biodiversity-related citizen science project – www.biodiversity4all.org, a Portuguese nationwide project – which represents the motivation to engage in an activity purely for the sake of the activity itself and strongly related with adherence and persistence.
The online survey asked about Interest/Enjoyment, Perceived Competence, Effort/Importance, Perceived Choice, Value/Usefulness, Relatedness and Group Relatedness, to evaluate intrinsic motivation for being involved and participating in the project and the way people participate. We also want to know what improvements can increase participation. A total of 149 answers were obtained, with most participants having higher education as academic qualification (83%). Participants with different levels of project's engagement have different intrinsic motivations to collaborate. Relatedness was one of the highest subscales, people valued the feeling of relationship with the project, while the Effort/Importance was the subscale less important. People who participate more have the highest levels of Perceived Competence.
Citizen science projects use many tools to induce citizens' participation, such as incentives, certificates of recognition and challenges, which can stimulate people's interest in the project. Nevertheless, these mechanisms should recognize the different potential motivations. Other values and emotional responses are needed by participants to support and maintain their involvement in a citizen science project after their initial participation, which is particularly important for the project's long-term sustainability.

## S7.13: Map of Life – supporting citizen science networks to map, report, and monitor species distributions

**Walter Jetz**
Yale University

I will elaborate on the central connection between representative species occurrence information and the measurement of diversity and its change. I will discuss recent advances in capturing global species distributions in a more integrated way, based on a combination of different data types and remote sensing information, and how in particular citizen science data can provide an immensely useful resource. I will illustrate the Map of Life project which set out to support this integration and the development of a more representative and sound species distribution for use in research, monitoring, and conservation. I will explain the different ways in which Map of Life can support amateur observer networks and incentivize citizen science engagement.

# Session 8: Thematic and Regional BONs

## S8.1: Regional monitoring activities in SASSCAL as related to the GEO BON goals

**Norbert Juergens**
University of Hamburg

SASSCAL, the Southern African Science Service Centre for Climate Change and Adaptive Land Management is a joint initiative and an institution of Angola, Botswana, Namibia, South Africa, Zambia, and Germany, responding to the challenges of global change (see www.sasscal.org). SASSCAL aims at the regional integration of scientific data that are relevant for adaptive land management in a framework of climate change and other environmental and societal changes. Therefore, climate, water, forestry, agriculture and biodiversity were identified as key thematic areas.
Within each of these areas new scientific monitoring activities have been established as parts of a research portfolio of 88 subprojects. For example, more than 130 new automatic weather stations have been established (see http://www.sasscalweathernet.org/).
A similar presentation of biodiversity observation products is presently in construction (see http://www.sasscalobservationnet.org/).
While there are several subprojects focussed only on biodiversity observation, also monitoring in the thematic areas agriculture, forestry, water and climate contribute to a larger observation system of the ecosystems in the region. Ground truth and remote sensing have been integrated, in many ways.
The SASSCAL observation component has also been planned as a full observation system that delivers useful knowledge to a wide range of users. This will be achieved based on the five National Nodes that have been established within each of the African countries. The delivery of knowledge will be supported by an Open Access Data Centre.
The SASSCAL observation contribution has been designed to support the goals of GEO BON. In cooperation with a similar Regional Science Service Centre in West Africa (WASCAL) it may also support the formation of an African regional BON.

## S8.2: Plant biodiversity in arid woodland savannas: trends observed over the past decade on four observatories along an aridity gradient in the Greater Kalahari in Namibia

**Ben Strohbach;** Emma Shidolo

Namibia University of Science and Technology

The Kalahari Basin in central southern Africa extends from the Northern Cape in South Africa to Angola, Zambia and the Democratic Republic of the Congo. The eastern third of Namibia's land surface is covered by this sand plateau with its notoriously nutrient-poor soils. This landscape is under severe threat by global climate change, with predictions of dune remobilisation over the next 50 years as far north as central Angola.
Four long-term biodiversity observatories have been established in this landscape in Namibia along an aridity gradient from roughly 500 mm precipitatioon per annum in the Kavango West Region (Mile 46 and Mutompo observatories), to 450 mm at Sonop observatory (Otjiozondjupa Region), to 350 mm at Sandveld observatory in the Omaheke Region.
With the help of long term data collected since 2001 (at Sandveld since 2005), we show that the savanna types change from a semi-open woodland dominated by broad-leafed tree species, to a semi-open bushland dominated by fine-leafed, shrubby Acacia species with only few scattered trees along the aridity gradient. The woody layers do not readily respond to climatic variations, but fire and andropogenetic influences (e.g. illegal felling of trees, clearing of fields) play a great role in the structure of these woodlands. The herbacious layer, in particular the grass sward, shows a stronger reaction to climatic variations: In the more xeric environments in central Namibia grass cover and composition follows strongly the amount of annual precipitation, whilst in the more mesic environment in northern Namibia the grass sward is more resilient to fluctuations in inter-seasonal rainfall. The land-use and fire frequency also has a strong influence on the degree of resilience, as shown by the observatory pair Mile 46 and Mutompo.

## S8.3: Influence of land use intensity on species size-class distribution and biomass in the Miombo Woodland, western Zambia

**Priscilla Sichone**
Universität Hamburg

With the ever-growing pressure on the African Miombo Woodlands due to harvesting of selected trees (in charcoal production and timber wood extraction) for commercial and domestic purposes, the loss of woodlands is a major concern. Land use, which includes activities that humans use to exploit land resources, can change the structure and functioning of Miombo Woodlands. The temporary or permanent reduction in density, structure, or productivity of forest cover needs to be assessed and often requires repetitive measurements of these structural attributes. The aim of this study is to assess the impact of land use activities on the structure and above ground biomass of Miombo Woodlands how this relates to different protection categories in western Zambia. Three Biodiversity Observatories (1 km x 1 km in size and subdivided into 100 hectare cells) approximately 100 km apart from each other in the Miombo Woodland of western Zambia were established. Within 20 randomly selected hectare cells per Observatory two nested plots of 100 m² and 1000 m² were sampled. In order to assess vegetation structure and above-ground biomass, we sampled diameter at breast height (DBH) and plant height for all the trees with DBH >5 cm for the 100 m2 plots and DBH >10 cm for the 1000 m2 plots. A cluster analysis will be performed in order to determine the slope of regression for size class distribution of the most abundant species. Regression curves will be established between dendrometric parameters (tree height, crown projected cover) and their estimated biomass relationships. The variance of structure of woody species and the biomass in the three Observatories is expected to indicate the influence of anthropogenic activities under different land uses.

## S8.4: Drivers of diversity and vegetation dynamics in the arid Succulent Karoo of South Africa – 15 years of annual vegetation monitoring

**Ute Schmiedel;** Jens Oldeland; Alexander Gröngröft; Norbert Jürgens
Universität Hamburg

The Succulent Karoo biome is a renowned centre of biodiversity and endemism and one of few biodiversity hotspots in arid regions (up to 80-250 mm p yr -1). The vegetation is dominated by leaf-succulent shrubs (mainly Aizoaceae, Asteraceae and Crassulaceae), which are accompanied by a high density of annuals (mainly Asteraceae and Scrophulariaceae) and monocotyledonous geophytes. The biome is prone to climate change, particularly increase in temperatures but also projected changes in rainfall patterns. The impact that these changes will have on the diversity and species composition is poorly understood.
The interdisciplinary BIOTA Southern Africa project implemented 37 standardised long-term biodiversity monitoring sites, so called biodiversity observatory, along a north-south transect from northern Namibia to the Cape in South Africa. Nine biodiversity observatories are situated in the Succulent Karoo. The BIOTA Biodiversity Observatories are 1 km² in size and subdivided into a grid of 100 1 hectare plots. Within 20 randomly-selected hectares per Observatory nested plots of 10 m x 10 m and 20 m x 50 m in size were permanently marked and several of them revisited annually from the year 2001 until to-date. The annual monitoring comprised the species inventory and projected cover per species for the 100 m² and 1000 m² plots as well as the assessment of abundance of individuals per species. In addition, the cumulative species inventory per hectare was determined. Environmental variables, like topography, soil surface structure, soil chemical and physical parameters were assessed as potential drivers of species composition and diversity. Standard weather variables (rainfall, air temperature and rel. humidity, wind direction and speed) were recorded by an automatic weather station next to the Observatory.
We will present the observed biodiversity patterns in space in time. The role of the mosaic of soil types as a driver of the patterns in species composition and diversity at different spatial scales will be discussed. A main focus of the study is the response of the vegetation dynamic to the inter-annual variance in weather conditions. In comparison with livestock enclosure plots we will also reflect on the relative impact of land use in comparison to inter-annual climate variables.

## S8.5: Monitoring biotic interactions of different complexity in highly variable dryland environments of the wider Namib Desert

**Norbert Jürgens**
University of Hamburg

The Namib Desert is one of the oldest dryland systems and it consists of several regional centres of biodiversity and endemism. Organisms are adapted to harsh environmental conditions

and to extreme temporal variability of rainfalls, especially in the regions that receive rainfall during summer.
Survival of populations is controlled by rare events that do allow the establishment of new cohorts. At the same time the synchronisation of the built-up or decline of populations of interacting organisms strongly governs the dynamics of the populations of the involved organisms. The impact of these interactions of several organisms in combination with human land use pressures on the diversity of species and ecosystems is still poorly understood.
Such interactive dynamics have been documented within several of the standardized in-situ square-kilometre-biodiversity observatories that were established since 2001 in the frame of BIOTA and SASSCAL.
The presentation will analyse three different levels of complexity (a) the dynamics of populations of the tree succulent Aloe dichotoma in the observatory Karios/Fish River Canyon (Namibia), (b) the dynamics of populations of the termite Psammotermes allocerus agg. within “fairy circles” in the observatories Dieprivier, Giribesvlakte and Featherlion Hill (all Namibia) and dynamics of species-rich leaf-succulent dwarf shrub communities in the observatories Numees and Koeroegabvlakte in the Richtersveld (South Africa)
The resulting population dynamics will be interpreted with regard to the adequate monitoring methods that involve various EBVs.

## S8.6: Establishing a monitoring system for diversity of above ground nesting solitary bees and wasps in Namibia, with regard to different fire regimes and management strategies

**Kristin Krewenka;** Kai Schütte
University of Hamburg

Insects and their interactions play a crucial role in delivering biotic ecosystem services. Bees are important pollinators of wild plants and crops, while wasps play a significant role in regulating other insect species populations and pest organisms and may function as pollinators.
Literature provides only marginal documentation for bee and wasp species in Southern Africa and is often limited to special sites (e.g. Succulent Karoo). The lifecycle and life history traits of the majority of occurring species, of which several are not taxonomically described, remain often unknown.
The Broad-leaf Savanna is an important ecosystem in Southern Africa, and is used for grazing by large herbivores and cattle. The degradation of this vegetation type, caused by intensive anthropogenic use and inadequate management practises like overgrazing and poorly conducted fire management schemes is an important topic in the conservation and restoration debate.
The impact of different fire regimes and growing grazing pressure on the diversity and the interactions of flower visiting bees and -wasps is until now not documented for this region and vegetation type.
Since 2014 standardized trap nests are used to monitor above ground nesting bees and wasps on the Waterberg Plateau in Namibia, within the framework of the SASSCAL project. These traps allow an assessment of the diversity of these organisms and the trophic interactions concerning their parasitoids and the feeding resources.
The monitoring will be extended to farm rangelands in 2016.
The presentation deals with the methodology and suitability of these traps for long term moni-

toring, shows first results of the obtained data and gives an outlook for future applications.

## S8.7: Understanding the fire regime of Southern Africa and its impacts on ecosystems

**Marion Stellmes[1];** David Frantz[1]; Manfred Finckh; Rasmus Revermann; Achim Röder; Vera De Cauwer; Anne Schneibel; Joachim Hill
[1] Trier University

Wildland fires are an important process for the ecology of African landscapes and are even vital for the maintenance, distribution and function of savannah ecosystems. Most of the fires in Northern and Southern Africa are of anthropogenic origin. These have been a part of the land use system for millennia and current landscape patterns are shaped by them. Fire is used as a tool to aid cultivation, e.g. in slash and burn agriculture, hunting, honey collection, charcoal production or pest control. Moreover, farmers burn grasslands to induce fresh growth to provide fodder for cattle. Many of the fires in woodland ecosystems of Southern Africa have their origin in these practices.
Changing boundary conditions, e.g. decreasing rainfall and/or land use change related to population growth, may have major implications for the fire regime and in consequence on ecosystems functioning and the provision of ecosystem services. Increasing fire frequency may cause land degradation and the loss of biodiversity as the fire regime has a profound impact on species composition and vegetation structure. To maintain current ecosystem services adapted fire management is required. The understanding of the specific consequences of fire in a given socio-ecological context offers new management perspectives to reduce ecological drawbacks. Therefore, it is indispensable to understand and describe all components of the prevailing fire regime. The key parameters that describe a fire regime are fire type, frequency, seasonality, and intensity whereby fire intensity is largely determined by fuel load, its heat yield and fire spread. For Southern Africa comprising the countries of Angola, Zambia, Namibia, Botswana and South Africa we characterized the fire regime based on an extensive multi-scale compilation of the MODIS products “Active Fire” (AF) and “Burned Area” (BA) covering the period 2000 to 2015 providing data with a spatial resolution of 1 km x 1 km and 500 m x 500 m, respectively. The integrated analysis of these mutually exclusive datasets allowed for a comprehensive spatio-temporal characterisation of important fire regime descriptors, such as the fire frequency, the seasonality and the intensity.
Moreover, we developed a novel object-based methodology that extracts valuable information about fire dynamics from BA data and provides highly valuable information about fire dynamics that were not spatially available up to now. Detailed information for every single fire regarding timing and location of its ignition is recorded, as well as detailed directional multi-temporal spread information. This information can in turn be intergrated to derive large-scale information for the entire study area and to improve understanding of the fire regime as such.
Subsequently, the combination of MODIS fire products and land cover information provided by e.g. phenology-based time series allows for ecosystem sensitive and spatially explicit analyses of fire patterns and fire risks. Based on the remote sensing derived descriptors it is possible to provide a detailed picture of the actual fire regime and its impacts on ecosystems with special regard to regional and local variations that often reflect climate gradients and vegetation cover.

## S8.8: Using the full depth of the Landsat archive to analyze post-war forest cover dynamics in Angola

**Achim Röder[1];** David Frantz[1]; Marion Stellmes[1]; Anne Schneibel; Valter Chissingui[2]M Manfred Finckh[3]; Joachim Hill[1]
[1] Trier University; [2] University of Lubango; [3] University of Hamburg

After more than two decades of civil war, Angola is presently experiencing dramatic socio-economic changes. The richness in natural capital (e.g. oil, uranium, diamonds) has promoted one of fastest-growing economies in Southern Africa, with growth rates of 8% in 2014. As part of the efforts to recuperate from the war, massive investments into infrastructure and building are being made, resulting in the establishment or upgrade of transportation networks, urban building schemes and plans to establish dams for electricity production along the streams. While urbanization is one major process reflecting this, the return of people to their former settlement areas has promoted increasing conversion rates of Miombo woodlands to cropland and the extraction of trees for charcoal production. In addition to this, Angola is expected to become a major producer of food for national and international markets, and large irrigation schemes are beginning to appear along major streams.
To date, a consistent, exhaustive assessment of deforestation dynamics, in particular after the end of the civil war, is still missing, and only isolated case studies exist. To achieve a synoptic view across the Miombo-Savanna transition zone, we employed the full Landsat archive available for Angola. Rigorous radiometric pre-processing has been applied, including automated cloud detection and masking, as well as spatially explicit modeling of the radiative transfer based on date-specific estimations of optical thickness and water vapor concentrations. To account for topography-induced illumination variations, a C-correction was employed.
Multi-seasonal, pixel-based composites were generated based on time-related seasonal breakpoints to derive large-area image datasets covering coincident phenological states of vegetation. Based on these composites, we mapped forest cover distribution and its temporal dynamics using hybrid classification and iterative spectral mixture analysis. Results of this were related to information on population density, hierarchical road network layers and the distribution of land mines, clearly illustrating spatial gradients of these drivers.
To understand the dynamics of shifting cultivation, in particular with respect to fallow dynamics, we used a time series segmentation algorithm (LandTrendr) on the full timeseries of available Landsat data. This allows identifying the year when fields were established and quantifying regrowth or reactivation dynamics afterwards, which is an important input to analyses on carbon stocks, biodiversity or ecosystem services that may be obtained from these areas.
These results are essential to understand how post-war demographic developments continue to affect the distribution and spatial configuration of forests, and subsequently support land management schemes facilitating the protection of Miombo forests and woodlands as major hubs of biodiversity as well as important sinks of carbon in southwestern Africa.

## S8.9: Water quality monitoring of the okavango Delta

**Wellington Masamba**
University of Botswana

The Okavango delta is an important wetland in north western Botswana. It is a Ramsar and a World Heritage Site. It is an oasis in the middle of the Kalahari Desert and provides all ecosystem services including provisioning services such as food, fuel and freshwater, regulating services such as flood regulation and water purification, cultural services such as recreation and ecotourism and supporting services such as nutrient cycling and primary production. People living in and around the delta, as well as wildlife therefore depend on the Okavango Delta. The high biodiversity is an important basis of Botswana's tourism.
Water quantity and the water quality key to the Delta's existence. In this study, the water quality of the water flowing into the Delta at Mohembo is presented. Generally, the water is of very good quality with electrical conductivity of less than 100 µS/cm, turbidity of less than 30 NTU and pH of between 5 and 8. Dissolved oxygen can vary between 3 to 9 mg/l. Other water quality parameters will be presented as will the relationship between water quality and discharge.

## S8.10: Automated interpretation of MODIS imagery flood extent as a proxy for monitoring floodplain plant communities in the Okavango Delta

**Michael Murray-Hudson[1];** Piotr Wolski[2]; Kgalalelo Thito[1]
[1] University of Botswana; [2] University of Cape Town

Characterising hydroperiod for flood-pulsed wetlands is a critical first step towards understanding their ecology and functioning. Earlier work has shown that the species composition and distribution of floodplain macrophyte communities along hydroperiod gradients in the Okavango Delta is a quantifiable function of frequency, duration, and depth of inundation. The annual pulsed inflow to the Delta propagates across the surface in an incremental fashion, with variable timing and depth, reaching a maximum extent around the end of August to early September.
In this paper, we present an approach for monitoring flood extent, based on the thresholding of the band 7 MODIS MCD43A4 product. We show that in the Okavango Delta, band 7 is superior to other spectral indices, and illustrate an innovative way of defining the spectral threshold used to separate inundated from dry land. The threshold is determined dynamically for each scene based on reflectances of training areas capturing end-members of the inundation spectrum. The method provides a very good accuracy and is suitable for automated processing. This is achieved based on a series of Python scripts which scan the USGS repository for the most recent imagery, download and process these, and post them to our Monitoring website, www.okavangodata.ub.bw/ori.
Because of the high temporal resolution (the method uses 8-day composites) the flood maps provide a near real-time representation of flood extent. Long-term flood frequency has been found to be the strongest predictor of macrophyte community composition. As we add to our time series, we expect our ability to map floodplain communities to improve. We have also developed a floodplain macrophyte distribution model based on mean monthly inundation duration which simulates community or species distributions under given hydrological regimes. Modelling species distributions based on mean flood duration of the preceding three years predicted species presence with 87% accuracy.

## S8.11: Monitoring wildlife movements in relation to resource availability in the Savuti-Mababe-Linyanti Ecosystem (SMLE) in Northern Botswana

**Keoikantse Sianga**
Okavango Research Institute

The size and stability of large herbivore populations is dependent upon the ability to adapt to strong inter-annual and inter-seasonal variation in forage quantity and quality, while minimizing the risk of predation. Thus, understanding and monitoring seasonal variations in habitat suitability in relation to a species' requirements at different stages in its reproductional cycle is essential to develop strategies for large, trans-national conservation areas and to mitigate conflicts between conservation and human land use.
The Savuti-Mababe-Linyanti region has been selected as an area to study and monitor seasonal resource utilization by buffalo and zebra. GPS collars were deployed to 3 buffalos and 6 zebras between 2011 and 2013 and allowed to monitor animal movements with ~ 6 occurrence points per day. Based on these, we interpreted field- and laboratory analysis of the movement of zebras and buffalos in relation to forage quality and quantity.
Zebra favoured open grasslands where the visibility is high and predation risk is low, whereas buffalo favoured both open and thick woodlands provided there is adequate forage and water for drinking. Zebra and buffalo migrated between their seasonal ranges as an adaptive strategy to forage dynamics and water availability. During the wet season, zebra used the Mababe short grassland and the Acacia hebeclada woodland short grasslands at Savuti in the Mababe Depression (MD) and sandveld woodland adjacent the depression where they obtained nutritious forage. Buffalo, however, moved into thicker woodland habitats where taller leafy grasses were common during the wet season which varied in forage quality and quantity. Buffalo herds used woodlands where visibility was low probably because they can defend themselves against their predators. Both species relied on ephemeral water in the pans during the wet season. When pans dried out during the dry season, zebra and buffalo moved to their dry season ranges around permanent water. During the early dry season, zebra used various woodland habitats adjacent the Linyanti Swamp and avoided floodplain grassland, but the buffalo used a range of woodland habitats and floodplain grasslands around the Selinda Spillway, Linyanti Swamps and Savuti Marsh.

## S8.12: Capacity building for the monitoring, reporting and verification (MRV) of biodiversity and ecosystem services in Africa

**Anne-Julie Rochette;** Maarten Vanhove
Royal Belgian Institute of Natural Sciences

With the adoption of the Strategic Plan for Biodiversity 2011-2020 and the Aichi Biodiversity Targets in the framework of the Convention on Biological Diversity, countries will have to formulate biodiversity indicators and gather data that will feed these.

The CEBioS programme is carrying out capacity building for partners of the Belgian cooperation in the field of biodiversity conservation and sustainable management linked to poverty eradication. It is hosted and implemented at the Royal Belgian Institute of Natural Sciences (RBINS). Improving the knowledge on Measurement, Reporting and Verification (MRV) of biodiversity, ecosystem services and related policy choices is one of its principal objectives.
We intend to work with our partner countries in the South on the development, assessment or implementation of indicators in the framework of their National Biodiversity Strategies. To that end, calls are launched annually since 2015 in order to provide funding and guidance to our partner countries. Partnerships were established with the GBIF, the Biodiversity Indicators Partnership (BIP) and Belgian experts for the capacity building components of these calls.
Two calls were launched so far, with two different approaches.
The first one mainly aims at setting national indicators for the follow-up of the NBSAPs. Selected projects are carried out in Morocco, Benin, Burundi and the DRCongo.
They address Aichi targets 5, 11, 14, and 18.
The second call focuses on the DRCongo and targets the follow-up of biodiversity at sub-national level. The themes are charcoal, bushmeat and fisheries. The projects focus here on existing biodiversity data, while the first call included data collection activities.
Our presentation will introduce the partnerships established to conduct the projects. They consist of a collaboration between a political authority (CBD National Focal Point, Ministry of Environment, regional biodiversity antenna…) and a research centre or university. This enables to improve the science-policy interface and to make scientific data usable for biodiversity policy.
We will address capacity building needs to establish indicators and follow-up processes. The first call was accompanied by a training session for representatives of each project. This workshop covered fields as diverse as ethnobotany, GIS, database management, biodiversity indicator development, ecosystem services valuation and project cycle management.
The capacity building approach for our second call will be adapted based on our first experience. We will discuss during this presentation the differences in needs considering the different scales and themes of the biodiversity monitoring projects in question.

## S8.13: Collection valorisation and stakeholder involvement for the sustainable management of African aquatic ecosystems as best practices in capacity building

**Maarten Vanhove**
Royal Belgian Institute of Natural Sciences

The services provided by freshwater ecosystems are numerous. Yet, these systems are under severe anthropogenic threat worldwide, and evaluation and mitigating these threats necessitates a wide multi-level and multidisciplinary approach covering the collection of baseline data, the involvement of stakeholders (ownership, accountability), and the strengthening of various technical, scientific and managerial skills.
Together with numerous international partners in the North and South, our team is involved in capacity building and research programs at different scales in different African regions. These efforts all aim at collecting policy-relevant biodiversity data, or stimulating cross-overs between data collection on the one hand, and community involvement or policy advice and governance on the other hand. Topics covered include invasive alien species, the development of decision

support systems including both technical and societal concerns around environmental conflicts, habitat monitoring and bio-indicators for pollution. Approaches central to some or all of these projects are the use of museum collections to assess anthropogenic impacts over time; stimulating linkages between local academia, civil society and policy makers; North-South-South collaboration; capacity building within, among others, Least Developed Countries.
We hope to stimulate discussion on what may constitute innovative "best practices" to ensure a sustainable biodiversity policy for African aquatic ecosystems. More specifically, we invite and propose strategies to (1) define what are policy-relevant data, (2) link the collection of scientific data with their translation into information relevant to policy and to society (bottom-up, civil society to top-down, decision makers) and (3) match the needs for capacity building with existing research interests/infrastructure, in order to constitute a structural contribution to awareness, assessment and management of African aquatic ecosystems and the anthropogenic influences they are facing.

## S8.14: Working together to develop biodiversity research and monitoring related capacities in the DR Congo

**Erik Verheyen**
Royal Belgian Institute of Natural Sciences

Worldwide millions of people rely on forests for food, medicines, energy and income. Indigenous groups depend almost entirely on them. It is anticipated that more economic activity may result in an increasingly rapid and chaotic development, with the destruction of natural resources and biodiversity as a consequence. There for policy makers worldwide are becoming more and more interested in preserving biodiversity. The relatively recent notion of ecosystem services rendered to human populations (locally and on a global scale) is gradually incorporated in the economic equation. Suspect and unlawful access to or acquisition of biodiversity (and/or related traditional knowledge) without prior informed consent by local stakeholders on the part of those whose biodiversity (or traditional knowledge) has been "accessed" or "acquired", is recognized as the nasty and ongoing issue of "bio-piracy". In addition to their ecological value, the forests of the Congo basin also represent an important resource for the country's economic development and the related political stability. Knowledge on a region's ecosystem can be thus become a powerful tool for those interested in increasing their economical and political power. With a surface of more than 2.0 million km2, the tropical forests in the DR Congo account for approximately 50% of the rain forests on the African continent, globally only surpassed in size by the tropical rain forests in the Amazon. Moreover, the Congo River is also of enormous importance as a freshwater resource, as it represents 25 % of the renewable water in Africa. From a global perspective, the main importance of the Congo basin is its uniquely rich biodiversity and its climate-relevant functions. In this context, the Congolese government has recently initiated efforts to ensure that the tropical forests will be exploited on a sustainable basis and that their biodiversity can be conserved. Because of its weakened institutional structures and its limited financial resources, the DR Congo solicits external support to rebuild its capacities in this regard. Only a solid knowledge base on the biodiversity in the DR Congo allows the reliable monitoring and control of the impact on forest biodiversity by logging, slash-and-burn agriculture practices, human-made bush fires, mining activities, and uncontrolled fishing practices and bush meat hunting.

During the International Year of Biodiversity and the 50th Anniversary of the Independence of the DR Congo, the Belgian government has favorably responded to this demand by Congolese authorities to empower the Congolese scientific community - and hence the Congolese society as a whole – to effectively deal with biodiversity issues. The recently launched Congo-2010 initiative initiates actions that target capacity building and addresses issues of deforestation, climate change and the sustainable exploitation of environmental and biological resources. A series of sub projects provide (i) specific training opportunities for Congolese scientists, (ii) access to an international network of experts that will contribute to Congolese research projects, (iii) a fully equipped centre of expertise for biodiversity at the University of Kisangani/Herbarium of Yangambi, (iv) support to strengthen the collaboration between the Congolese and Belgian institutions to initiate the inventory of the poorly know biodiversity in the Congo basin, a prerequisite to reliably assess the environmental consequences of increased human activities over the last decades.
The two most unusual activities that were carried out to reach the goals listed above was the execution of an international multidisciplinary expedition on the Congo river, allowing some 65 researchers of the DR Congo, Belgium and other countries to work side by side to (i) document biodiversity and environmental conditions along the Congo river, (ii) provide the first data for the identification of new potential protected areas in and along the river, (iii) collect biological material embedded in a matrix with specific environmental data that can be studied both in DR Congo and abroad, (iv) produce a taxonomic revision and inventory of selected animals and plants and their characterization with DNA methods, (v) produce data suited for the study of the global C-balance (climate change), (vi) produce state of the art navigation maps for the Congo River and (vii) produce environmental measurements that will allow evaluating the relevance and validity of data collected through remote sensing. These activities are focused on areas situated outside the protected areas in the region, where the future loss in biodiversity is anticipated to be most severe. In order to monitor biodiversity and environmental changes through time, a permanent sampling station will be set up to carry out detailed quantitative sampling out to create the very first baseline collection and data base that will allow to compare results on seasonal and human-induced changes in the terrestrial and aquatic natural habitats of the Congo basin area.
Subsequent to this field campaign, the Congo2010 consortium developed the Centre de surveillance de la biodiversité (CSB) in Kisangani to rebuild the local infrastructure and to develop a solid knowledge base on the biodiversity in the DR Congo. This approach is intended to facilitate the reliable monitoring and control of the impact on forest biodiversity by logging, slash-and-burn agriculture practices, human-made bush fires, mining activities, uncontrolled fishing practices and bush meat hunting.
Our presentation will introduce three ongoing projects in Kisangani (Congo2010/CSB, IMAB/CeBIOS & VLIR CUI-Unikis) that each in a different way, contribute to increased local expertise, the valorization of biological resources through sustainable exploitation, and a better knowledge of the biodiversity in the Congo Basin. Arguably, these projects contribute to the empowerment of the Congolese scientific community, and the Congolese society as a whole.

## S8.15: Capacity building, prioritization and definition of biodiversity monitoring indicators in Benin

**Tewogbade Jean Didier Akpona[1];** Hugues Akpona[2]; Chabi Adeyemi; Marc Sylvestre Djagoun[1]

[1] Université d'Abomey-Calavi; [2] Ministry of Environment and Protection of Nature

Benin Republic, ratified like several other countries in the world the Convention on Biological Diversity and developed its new biodiversity strategy and action plan (NBSAP) organized in 5 axes and 7 strategic goals, 20 objectives and 75expected results. Lessons learnt from the process of reporting on previous NBSAP showed that it was almost impossible to assess progresses because indicators defined were too ambitious, sometimes far from national realities and generally too expensive to measure. In this regards, they are an obstacles to the national biodiversity monitoring and reporting. However an important element of the new generation of NBSAPs, is monitoring progress towards achievement of national goals to guide implementation and facilitate the preparation of national reports. In that regard, Benin conducted with the financial support of CEBIOS a consultative process to identify, select indicators based on criteria define in a participatory approachand develop proposals for baseline data collection on indicators. This work aimed to contribute to the implementation of the Strategic Plan for Biodiversity 2011-2020 by strengthening the capacity of national stakeholders on the content of the NBSAP and selecting five (05) priority goals for Benin biodiversity conservation in order to develop the priority and effective indicators to attend each goal. Several actors were included in the process from various sectoral ministries related to biodiversity issues, lecturers, researchers, NGOs, ministry officers, foresters and other key persons.
The methodology consisted of a series of discussions, plenary work for the definition of criteria and the selection of priority objectives and key indicators in working group for the definition of indicators. Feedback sessions and a very enriching debate to validate the results of each working group were organized and helped to define key challenges for each selected indicator. The actors became familiar with the methodology and the different stages of the development of biodiversity indicators framework.
A total of 5 objectives were selected among the 20 defined in the NBSAP following a screening based on selected criteria. 15 indicators were identified (three per 5 strategic objective of NBSAPs). A quality assessment of each indicator was done based on defined criteria and at least 5 relevant indicators were retained, reducing the long list of indicators to the five most important to monitor progresses in the NBSAP implementation.
Keywords: NBSAPs, biodiversity indicators, national stakeholders, Benin.
Note: Please note that I would only be able to attend the conference if GEOBON could support my participation and venue.

## S8.16: Capacity building to define the trends of ecosystems, to assess ecosystem services and to monitor and report the status of biodiversity based on indicators in Burundi

**Benoit Nzigidahera[1];** Bernadette Habonimana[2]
[1] Office Burundais pour la Protection de l'Environnement; [2] Université du Burundi

Burundi has established indicators for the follow-up of the implementation of its new National Biodiversity Strategy and Action Plan (NBSAP 2013-2020) and for the monitoring of the state of its biodiversity.
By analyzing the indicators of national objectives 5,7,13 and 15 related to the trend of biodiversity and ecosystems providing ecosystem services, we noticed that they are not all based on

defined quantitative data. It became obvious that the formulated indicators fail to analyze the trend of biodiversity in several ways. Moreover, they do not refer to any established baseline.
In order to rectify that trend a capacity building programme was established between the Royal Belgian Institute of Natural Sciences (RBINS) and the Office Burundais pour la Protection de l'Environnement (OBPE) to establish baseline situations with reliable and well-recorded data and improve the formulated indicators and the communication mechanism for NBSAP implementation. This capacity building programme includes:
- Strengthening the research leading to a better understanding of habitat changes and their impact on species and interactions of fauna and flora in protected areas. This is reflected with the establishment of the habitats monitoring system and the calculation of trends in the extent of ecosystems and selected natural habitats.
- Strengthening scientific research and training specifically related to a number of species selected for their high potential as carriers or providers of ecosystem services, as some plants (rattan and bamboo), pollinators and fungi, and conducting further studies on the economic value of selected ecosystem services.
- Establishing a functional mechanism to measure, track and report the status of biodiversity on the basis of indicators to formulate and strengthen the Clearing-House mechanism (CHM) to promote the dissemination and reporting of Burundi interventions to achieve the 2020 Aichi biodiversity targets through databases, the CHM website and the online reporting system.
In addition to these activities conducted in collaboration with the RBINS, the OBPE in collaboration with the University of Burundi is currently consolidating structures for the monitoring of biodiversity and ecosystem services at the national level. This framework enabled to highlight major needs for capacity building to establish a permanent framework for the monitoring and reporting of the trend of biodiversity and ecosystem services on the basis of constantly renewed indicators.
Note: Financial support is requested for my participation to the conference. Thank you for considering it.

## S8.17: Studying great apes synergistically across levels of biological organization: A hierarchical concept for global biodiversity monitoring and research

**Hjalmar Kühl[1];** Tene Sop
[1] MPI EVAN

A trade-off exists in obtaining highly detailed biological information for a limited number of individuals versus much coarser information with reduced biological content at the species level. Both ends of this spectrum are necessary for addressing different sets of questions on all aspects of biodiversity. Practical research requirements regarding information quality necessitate pragmatic solutions for data collection in the respective situation. In the ongoing debate about how to monitor biodiversity with all its facets most effectively across spatio-temporal scales and understand basic principles of its organization, recent developments in research and monitoring of 13 African and Asian great ape taxa may provide highly beneficial insights. The study of individual great apes at long-term sites provides longitudinal information on demography, physiology and behavior on a local scale; the study of ape communities at a regional scale provides cross-sectional information on the ecological and genetic differentiation of populations; continental scale studies provide insights into species distribution, total abundance and temporal trends. Integrating this scale-dependent information provides invaluable synergies e.g. to understand the emergence of regional behavioral patterns from local scale ape-environment interactions, or to identify local to regional scale conservation priorities from taxon level information. Synergies are enabled by uniform data collection protocols and standardization of heterogeneous data sources for compatibility and integration of information across scales. In combination, this concept provides a very powerful approach for addressing a wide spectrum of research questions which is impossible to do when focusing on a single scale alone. The key challenge to and required investment into such a hierarchical research and monitoring approach is the set-up of a viable logistical infrastructure for collection and centralized archiving of data, including data distribution policies as well as a functional network of collaborating institutions. Such approach can be simultaneously used for research and monitoring of a wide spectrum of species and their environments.

## S8.18: Incorporating habituated great ape research into a regional perspective: Life at the edge of the chimpanzee (Pan troglodytes verus) range

**Erin Wessling[1];** Tobias Deschner[1]; Viktoria Oelze[1]; Jill Pruetz[2]; Michael Richards[3]; Hjalmar Kühl[4];
[1] Max Planck Institute for Evolutionary Anthropology; [2] Iowa State University; [3] Max Planck Institute for Evolutionary Anthropology/University of British Columbia; [4] German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig/Max Planck

The chimpanzees (Pan troglodytes verus) inhabiting the savanna-woodland environments of southeastern Senegal represent the northern-most chimpanzee population on the continent. While therefore marginal by geographic definition, this population is often considered to be likewise at the climatic extremes of their range with less than 1000mm rainfall confined to only a 4-month period and daily maximum temperatures frequently exceeding 40°C. The nature of this range margin is not well understood despite the implications that such a structure has on our understanding of chimpanzee ecology and biogeography. Here we describe a multi-level approach to examine the determinants of the chimpanzee range margin as a function of seasonally-induced ecological and climatic stress.
First, we compared patterns of seasonally-induced patterns of nutritional, water, and heat stress chimpanzees from one habituated chimpanzee community living in savanna-woodland habitat (Fongoli, Senegal) with that of another habituated community living in tropical rainforest (Taï National Park, Cote D'Ivoire). Although moderate seasonal fluctuations in rainfall and food availability are known to occur at Taï, seasonal variation in nutritional and water availability is less pronounced, and these chimpanzees are not expected to experience stress associated with heat or dehydration to the same extent as Fongoli chimpanzees. Here we combined hormonal, ecological, climatic and behavioral data to evaluate the role of surrounding habitat on seasonal stress patterns as well as the behavioral mechanisms chimpanzees are thought to employ in order to cope with this stress.
Secondly, we place observed temporal variation in seasonal stress of Fongoli chimpanzees into the context of the range margin itself, to elucidate constraints associated with living at the West African chimpanzee northern range limit and their ecological correlates. This is accomplished by comparing sequential stable isotope data obtained from hair segments collected non-invasively from the Fongoli community as well as four unhabituated chimpanzee communities located along a north-south gradient in southeastern Senegal. Isotope ratios in plant food items

at these sites were analyzed to provide a dietary baseline for these chimpanzee communities. Understanding this variation in isotopic profiles elucidates patterns regarding the nature of the range margin itself. Overall, these comparisons allow us to first understand what stresses chimpanzees over time at a local scale at the range margin, while further extending our understanding to how these experiences likely affect chimpanzee distribution at the regional scale.

## S8.19: The Pan African Programme: The Cultured Chimpanzee - Video, Organic And Ecological Sampling At 40 Temporary Research Sites Across Africa

**Mimi Arandjelovic[1];** Christophe Boesch; Paula Dieguez; Maureen McCarthy; Vittoria Estienne; Erin Wessling; Nuria Maldonado; Hjalmar Kühl
[1] MPI for Evolutionary Anthropology

Effective conservation planning requires more than just knowledge of a species' distribution and population size but also an understanding of their ecological, behavioral and genetic diversity. The Pan African Chimpanzee Programme: The Cultured Chimpanzee (PanAf) is a large-scale, continental-wide, research project aimed at understanding and modeling the socioecological and demographic drivers of chimpanzee (Pan troglodytes) diversity. Established in 2010, we have been collecting directly comparable data from 40 temporary and collaborative research sites in 14 countries across Africa spanning the entire range of the four chimpanzee subspecies. Sites were selected systematically based on geographic location within the species' range and established for a duration of 12 to 20 months. A detailed field protocol based on non-invasive methods was developed and all field team managers underwent a mandatory training workshop to familiarize themselves with all data collection procedures. Data collection at each temporary field site includes undertaking over 50 kilometers of reconnaissance walks (recces) to first establish the site by confirming ape absence or presence in areas which were previously data deficient. Then, various survey and monitoring techniques are used to record habitat and dietary characteristics along with innovative approaches such as camera traps for assessing biodiversity and chimpanzee group demography. Additionally, we collect organic materials for analyses on pathogen loads, stable isotopes to estimate dietary intake, genetic samples to determine chimpanzee population history, and carrion flies containing eDNA to assess biodiversity levels. The analysis of these large data sets has required the implementation and assessment of various novel techniques. For example, in partnership with Zooniverse, the online citizen science platform Chimp&See (www.chimpandsee.org) was developed for identifying the wildlife species and behaviours present in over 350,000 1-minute camera trap videos. Furthermore, we established a system to identify all unique chimpanzee individuals from these videos using crowd sourced analyses. We compare the accuracy and efficiency achieved by the general public on this platform to automated facial detection software and expert scientific annotators. Our system of temporary research sites has proven successful in gaining new insights into chimpanzee behaviour, culture, demography, health status and social networks in previously unknown or poorly-studied populations while simultaneously, documenting the sympatric flora and fauna at each site. We therefore propose that the PanAf project demonstrates an effective monitoring strategy for studying and protecting apes, their habitats and sympatric species and could be easily adapted for other species with large ranges. Moreover, our approach to standardized methodology and comparable data collection across multiple research sites could be used to globally monitor and protect biodiversity.

## S8.20: IUCN SSC A.P.E.S. Database: A tool to support great apes conservation and research

**Tenekwetche Sop[1];** Louwrens J. du Toit[2]; Hjalmar Kühl
[1] German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig/Max Planck Institute for Evolutionary Anthropology; [2] German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig/Max Planck Institute for Evolutionary Anthr

It is well known that the lack of knowledge, and access to data, hampers assessments on the status of biodiversity. This is particularly true for all great apes taxa, which are all listed as endangered on the IUCN Red List of Threatened species.
The IUCN SSC A.P.E.S.* database is a repository of great ape data from populations' surveys contributed by conservation NGOs and scientists worldwide. Its aim is to inform decision making process for great ape conservation efforts at national and international levels, by providing information distribution, total abundance and temporal trends of great apes. In combination with various remote sensing data, the A.P.E.S. database is a powerful tool to understand ape-environment interactions, observe and monitor the drivers of population change, and for identification of local to regional scale conservation priorities of great apes at taxon level.
Here we report on concrete applications of the IUCN SSC A.P.E.S. platform and highlight how long-term monitoring data across spatio-temporal scales can be valuable for analysis of trends in African great ape populations, compilation of abundance from various sites, modeling species/subspecies niches and identification of priority conservation areas with high co-benefits for biodiversity and ecosystems services, and for great apes conservation in particular. From this perpspective, the A.P.E.S. database serves the needs of the CBD and IPBES.
As a repository for great ape population's data, the A.P.E.S. database allows users, via the APES portal (http://apesportal.eva.mpg.de/) to find and request survey resources which are grouped by country, site, taxon, survey method, etc., as well as field reports. The IUCN SSC A.P.E.S. database is governed by a very strict data sharing policy which ensures that archived data remains the property of their contributors. This aims at encouraging the great ape community to confidently share their survey data with the IUCN SSC A.P.E.S. database. However the main challenges remain to convince data owners to provide information and to pool all the received data from various sources in a unified format suitable for the database and that can be easily visualise from a user interface.
* A.P.E.S.: Ape populations, environments, and surveys; SSC: Species Survey Commission

## S8.21: Remote sensing for biodiversity monitoring: opportunities and challenges

**Nathalie Pettorelli**

Habitat loss and degradation, overexploitation, climate change and the spread of invasive species are drastically depleting the Earth's biological diversity, leading to detrimental impacts

on ecosystem services and human well-being. Our ability to monitor the state of biodiversity and the impacts of global environmental change on this natural capital is fundamental to designing effective adaptation and mitigation strategies for preventing further loss of biological diversity. This requires the scientific community to assess spatio-temporal changes in the distribution of abiotic conditions (e.g. temperature, rainfall) and in the distribution, structure, composition and functioning of ecosystems.
The potential for remote sensing (RS) to provide key data for monitoring and managing biodiversity has been highlighted by many researchers. RS indeed permits one to address questions on scales inaccessible to ground-based methods alone, facilitating the development of an integrated approach to natural resource management, where biodiversity, pressures to biodiversity and consequences of management decisions can all be monitored.
Here, I will provide an interdisciplinary perspective on the prospects of remote sensing for biodiversity monitoring, reviewing established avenues and highlighting new research and technological developments that have a high potential to make a difference in environmental management. I will also discuss some of the current barriers to the application of RS-based approaches and identify possible ways forward.

## S8.22: Passive acoustic monitoring (PAM) of primates: progress and challenges

**Ammie K. Kalan[1];** Alex K. Piel[2]; Stefanie Heinicke[1]; Hanna Lukashevich[3]; Roger Mundry[1]; Oliver J. J. Wagner[1]; Roman M. Wittig; Christophe Boesch[1]; Hjalmar Kühl[4]
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Remote sensing has emerged as an attractive, cost-efficient alternative to traditional biomonitoring methods that usually require a longer term investment and greater manpower. These new technologies permit wildlife surveys to be conducted at larger temporal and spatial scales where data on species' range and occurrence can be updated quickly, which is essential for effective wildlife management in the current biodiversity crisis. Here, we developed a novel passive acoustic monitoring (PAM) tool for wild primates and demonstrate its potential as an effective means of biomonitoring in tropical regions. Using 20 autonomous recording units (ARU), we collected over 12,500 hours of audio data across seven months at the Taï National Park in Côte d'Ivoire. After building a training library of sounds produced by the King colobus (Colobus polykomos), diana monkey (Cercopithecus diana), and the chimpanzee (Pan troglodytes verus), we developed a customized algorithm for the automated detection and classification of these target sounds from continuous rainforest recordings. Although a validation study demonstrated that our algorithm results still required some manual verification, the time saved using such an automated approach was over 96%, and therefore demonstrates the benefit of automated data processing for methods that amass large datasets. We were able to show how primate call detections could be used to model the probability of species occurrence, and that our occupancy estimates were robust to the degree one can manually clean the automated ARU data. Importantly, our results were also comparable to occupancy estimates derived from data collected by human surveyors in the same study area. Therefore, we suggest that longitudinal monitoring of calling rates via PAM could provide additional information on population shifts and loss, thereby acting as a potential early-warning system for wildlife management programs for a variety of species. In a recent follow-up study conducted in collaboration with another chimpanzee (Pan troglodytes schweinfurthii) field site in Issa, Tanzania, we tested more detailed hypotheses on chimpanzees using long term data collected from West and East African research sites. We demonstrated that indirect signs of chimpanzees at Issa (e.g., sleeping nests and feces), and direct observations of chimpanzees ranging at Taï, were both significant predictors of detecting chimpanzee sounds within a maximum one kilometer radius of an ARU, at the two study sites. This further suggests that wildlife movements and group ranging behaviour can also be accurately monitored and researched using PAM. Our approach for forest primates can be easily replicated for other vocal, territorial taxa with large ranges but will benefit most from collaborations with acoustic engineering and sound professionals in order to further develop automated data processing methods so that field practitioners can get the most from this powerful new tool.

# Poster Sessions

## Biodiversity

### P1.1: Biodiversity monitoring in a changing world: an integration of established approaches with emerging technologies

**Kalkidan Mulatu[1];** Mora Brice; Lammert Kooistra; Douglas Yu; Martin Herold[1]
[1] Wageningen University

Tropical forests are complex ecosystems that hosts the most diverse flora and fauna species on earth. However, they also face the most complex disturbance events from anthropogenic and natural sources, thus requiring more advanced biodiversity monitoring system to evaluate species composition dynamics.
We performed a literature review to assess biodiversity change monitoring techniques employed in disturbed tropical forests. Furthermore, the study explored avenues of methodological integration between monitoring techniques for establishing a comprehensive monitoring approach. Such an approach that is based on reliable indicators and proxies can bridge research gaps and contribute to conservation efforts such as those from the United Nations Convention on Biological Diversity (UNCBD)
With a systematic scientific literature search, 84 papers were chosen where their biodiversity monitoring components were elaborately analysed. Criteria for analysis were: disturbance type, target groups studied, variables measured, monitoring approaches employed, and their relation to the current list of Essential Biodiversity Variables (EBV's) proposed by the Group on Earth Observations Biodiversity observation Network (GEO BON).
The preliminary results confirmed that anthropogenic pressures via agricultural activities, extraction of wood products, construction, hunting, mining and energy purposes are the major causes of disturbance in tropical forest, while disturbances related with natural scenarios such as El-Nino and diseases accounts for much less. The established in-situ methods appear to be predominant for monitoring of biodiversity change for all disturbance types. Remote sensing

techniques were employed mainly for the monitoring of biodiversity changes due to anthropogenic disturbances, especially those resulting from agriculture and extraction of wood products, while its application was limited where disturbances were occurring due to mining, diseases, and natural scenarios. The most studied biological groups were vegetation, arthropods, birds, and mammals. These groups were mainly monitored with established in-situ approaches, except in the case of vegetation and habitat monitoring which were mainly studied using remote sensing techniques. On the contrary, remote sensing had limited application towards monitoring of arthropods, birds, and mammal groups. Meanwhile, DNA metabarcoding technique has been applied only for the monitoring of vegetation and arthropods. The temporal trend from the reviewed papers indicated the growing tendency towards integration of monitoring methods, where especially from the year 2009 onwards remote sensing techniques, activity sensors and DNA metabarcoding techniques have been increasingly incorporated in monitoring systems.
All the EBV classes except genetic composition have been addressed by remote sensing techniques. However, this gap can be complemented by established in-situ and DNA metabarcoding methods. The preliminary results indicated the limited use of remote sensing, activity sensors, and genomic technologies which however has a high potential to pick on subtle changes in complex environments.
Even though the biodiversity monitoring approaches are still dominated by established in-situ methods, it is becoming clear that to develop a better understanding of the complex biodiversity of tropical forests, an introduction of emerging technologies is necessary. Such new technologies provide new opportunities to improve the measurement of key environmental indicators (e.g., forest structure) that can be related to biodiversity dynamics. Hence, such new technologies can help in building better monitoring systems. The integration of these data streams still remain a challenge that the remote sensing and biodiversity community needs to overcome to improve the measurement of indicators related to the Aichi targets, and the newly proposed Sustainable Development Goals (SDGs).

## P1.2: Towards global interoperability for supporting biodiversity research on essential biodiversity variables (EBVs)

**Daniel Kissling[1];** Alex Hardisty; Enrique Alonso García; Monica Santamaria; Francesca De Leo; Graziano Pesole; Jörg Freyhof; David Manset; Silvia Wissel; Jacco Konijn; Wouter Los
[1] University of Amsterdam

Essential biodiversity variables (EBVs) have been proposed by the Group on Earth Observations Biodiversity Observation Network (GEO BON) to identify a minimum set of essential measurements that are required for studying, monitoring and reporting biodiversity and ecosystem change. Despite the initial conceptualisation, however, the practical implementation of EBVs remains challenging. There is much discussion about the concept and implementation of EBVs: which variables are meaningful; which data are needed and available; at which spatial, temporal and topical scales can EBVs be calculated; and how sensitive are EBVs to variations in underlying data? To advance scientific progress in implementing EBVs we propose that both scientists and research infrastructure operators need to cooperate globally to serve and process the essential large datasets for calculating EBVs. We introduce GLOBIS-B (GLOBal Infrastructures for Supporting Biodiversity research), a global cooperation funded by the Horizon 2020 research and innovation framework programme of the European Commission. The main aim of GLOBIS-B is to bring together biodiversity scientists, global research infrastructure operators and legal interoperability experts to identify the research needs and infrastructure services underpinning the concept of EBVs. The project will facilitate the multi-lateral cooperation of biodiversity research infrastructures worldwide and identify the required primary data, analysis tools, methodologies and legal and technical bottlenecks to develop an agenda for research and infrastructure development to compute EBVs. This requires development of standards, protocols and workflows that are 'self-documenting' and openly shared to allow the discovery and analysis of data across large spatial extents and different temporal resolutions. The interoperability of existing biodiversity research infrastructures will be crucial for integrating the necessary biodiversity data to calculate EBVs, and to advance our ability to assess progress towards the Aichi targets for 2020 of the Convention on Biological Diversity (CBD).

## P1.3: Tortoise species diversity across an aridity gradient in Namibia, as observed at long-term biodiversity observatories

**Klaudia Amutenya[1];** James Juvik[2]; Jill Heaton[3]
[1] Namibia University of Science and Technology; [2] University of Hawaii; [3] University of Nevada, Reno

Little attention has been given to the reptile species diversity at the biodiversity observatories in Namibia during the past years. Yet, in particular the slow-moving tortoises are ideal indicators of long-term climatic changes, as their populations are highly susceptible to climatic variations. With this study, we determined the species diversity of tortoises at the main biodiversity observatories along a rainfall gradient from northern Namibia (ca 600 mm annual precipitation) to southern Namibia (ca 150 mm annual precipitation). In the process, we were able to proof a slight range extension of all three species observed beyond currently known ranges.

## P1.4: Biological Field Stations: a pivotal infrastructure for global environmental research

**Laura Tydecks[1];** Vanessa Bremerich; Klement Tockner; Ilona Jentschke; Gene Likens
[1] Leibniz Institute for Freshwater Ecology and Inland Fisheries

Biological field stations (BFS) constitute a global network for long-term environmental monitoring and research, education, and public information. On the basis of a comprehensive inventory, we identified 1268 contemporary BFS, located in 120 countries. BFS occur in all biomes and cover terrestrial, freshwater, and marine systems, with the majority situated in protected areas. BFS offer a unique opportunity to improve our understanding on pressing environmental and social challenges and therefore deserve utmost support to fulfill their pivotal role at the regional and the global scales.

## P1.5: An integrated biodiversity assessment to achieve Aichi Biodiver-

## sity Targets 11 and 15 in Mexico

**Wolke Tobón;** Tania Urquiza-Haas; Patricia Koleff

Mexico has committed to protect at least 17% of terrestrial and 10% of marine areas of particular importance for biodiversity, and to restore 15% of degraded ecosystems. To expand the protected area network and establish other area-based conservation measures that support the achievement of national and international conservation goals, clear, relevant, reliable and updated information needs to be provided to decision makers, stakeholders and practitioners. The National Commission for Knowledge and Use of Biodiversity (Conabio) compiles, integrates, analyzes and guarantees open access to vast information on living organisms and ecosystems and their numerous components of the country. In the context of the CBD Program of Work on Protected Areas, this information has been used to identify priority sites for conservation of terrestrial, freshwater and marine biodiversity and to detect conservation gaps in the protected area network which represent a clear input for policy making. The process was based on systematic conservation planning and involved the participation of more than 260 stakeholders from government, non-governmental organizations and experts from academic institutions.

Following up on these conservation assessments allowed us to integrate results at a finer scale and also to incorporate new biological and socio-economic information. Two sets of complementary priority areas between each other resulted from the integration using spatial multi-criteria evaluation. One set of sites focused on areas of high importance for conservation importance given their biodiversity value, closeness to current protected areas, minor levels of land use intensity, low fragmentation, low impact of infrastructure, but high risk of deforestation in order to promote in situ protection in these areas. A second approach targeted priority sites for restoration, i.e. areas with high conservation value but where biodiversity is compromised by different threats, such as soil degradation or fragmentation, but where restoration measures are more feasible. The synthesis of available and spatially explicit knowledge on biodiversity and anthropogenic drivers of environmental change represents a comprehensive collective and transdisciplinary effort, unprecedented in Mexico and other countries that provides updated insights into conservation needs and facilitates the implementation of diverse conservation instruments to fulfill biodiversity goals.

# Ecosystem Services

## P2.1: A long-term monitoring program on the impacts of coral bleaching on ecosystem services in Thai waters

**Thamasak Yeemin;** Wichin Suebpala; Makamas Sutthacheep; Sittiporn Pengsakun; Watchara Samsuvan; Juthamart Putthayakool; Monthaphat Thummasan

Coral reef ecosystems provide a lot of economic benefits, especially reef tourism, recreational fisheries, fisheries production, shoreline protection and natural products. However, coral reefs are threatened by various anthropogenic and natural disturbances. Determining how ecosys-

tem services are associated with biodiversity is required for investigating the consequences of biodiversity loss and for setting objectives and priorities for coral conservation and management. Studies on functional redundancy within coral communities, the number of taxonomically distinct species that show similar ecological functions, are very important for understanding the consequences of biodiversity loss. A case study in the Gulf of Thailand revealed that the low Acropora coverage at the study sites before the 2010 coral bleaching event was still a result of the previous severe coral bleaching in 1998. Densities of juvenile Acropora colonies before the 2010 coral bleaching event were also very low at the study sites, with no recruitment for several years. Several Acropora species that were previously observed in these areas are presently at risk for local extinction.
Coral reef ecosystem services in the Gulf of Thailand and the Andaman Sea have been quantitatively investigated with emphasis on linking coral reef conditions with various types of ecosystem services. Given coral reef management and restoration plans in Thailand as an example, the coral reefs are categorized into four different groups depending on their threats and type of uses. The coral reef that is in a degraded status and is used for tourism is the priority area for coral reef restoration. The coral reef restoration plan concentrates on using passive restoration in 4 strategies and 15 measures, by reducing threats from tourism, water pollution, sedimentation and fisheries. The active coral restoration techniques should be simple and cheap methods, community involvement, high tolerant species to bleaching and multi-species transplantation. The coral reef management and restoration project was initiated and funded by the network of provinces in the eastern Thailand. It aims to survey and establish an ecological and socio-economic database for managing the coral reefs and enhance their resilience to climate change.
In addition, artificial substrates for coral recruitment and ecotourism are provided at tourist hotspots with the participation of local communities in managing natural resources and environment, wherein public awareness and education are enhanced. The project shows effective collaboration between scientists, local communities and local government officials as decision-makers to integrate scientific data into policy and adaptation measures. The coral reef restoration sites can be used to support ecotourism and learning opportunities for students. Continuing efforts in capacity building, public awareness and education through disseminating printed materials and conducting training courses, workshops and seminars for stakeholders, youth, students and local government officials can enhance resilience in coastal communities. Strengthening the long-term monitoring, evaluation and reporting of the project can provide lessons for conservation of coral reefs in tourist hotspots influenced by climate change, especially coral bleaching events. This study highlights the importance of long-term coral reef monitoring program for effective management.

## P2.2: Tree biodiversity influence on cooling effects of urban green spaces in Leipzig, Germany

**Madhumitha Jaganmohan**
As cities are growing warmer there is a dire need to bring about local climate regulation as a mitigation measure. Vegetation in urban green spaces (UGS) is being increased in many cities globally for the purpose of lowering temperatures. Studies in urban environment suggest positive relationships between various measures of vegetation diversity and ecosystem services. To further understand the relationship between biodiversity and local climate regulation in urban areas, 54 UGS were studied in the city of Leipzig, Germany. Our main hypothesis was that biodi-

versity has a positive effect on local climate regulation. Mobile air temperature measurements were performed in the UGS and its surrounding along a transect. From the observed temperatures using a fitted polynomial function, the indicators of cooling effect were calculated: the maximum ΔT (the maximum temperature difference between the UGS boundary and the surrounding area) and the cooling distance (the distance at which the maximum cooling is experienced from the boundary of the UGS). The different aspects of tree biodiversity such as species diversity, functional diversity and mean traits were also sampled in the same UGS. Multiple regression models were used to examine the effects of these three aspects of biodiversity on the cooling effects of UGS along with the physical characteristics of the UGS and their surroundings. The results suggest that aspects of functional diversity rather than diversity of tree species increase the cooling effect in UGS. Thus, this study provides insights regarding the importance of species diversity vs. functional diversity and mean traits of tree vegetation in the cooling effect in UGS, which may guide effective management and conservation strategies in urban environments.

## Remote Sensing

### P3.1: The Copernicus Global Land Service: The Moderate resolution Dynamic Global Land cover layer

**Ruben Van De Kerchove[1];** Luc Bertels[1]; Nandin-Erdene Tsendbazar[2]; Myroslava Lesiv[3]; Steffen Fritz[3]; Martin Herold[2]; Bruno Smets[1]
[1] VITO; [2] Wageningen University; [3] IIASA

Here we present the methodology and rationale behind the upcoming Moderate resolution Dynamic Global Land cover layer which is foreseen to be one of the new products in the framework of the Copernicus Global Land Service. This layer will complement several global land cover 'epoch' datasets which have been created at medium (and high) spatial resolution during the last decade by providing a yearly dynamic land cover layer at 100m resolution. To build this layer, 100m spatial resolution PROBA-V data (acquired every 5 days) will be used as primary EO data. Several data fusion techniques will be applied: First, the 5-daily PROBA-V100 m and daily 300 m datasets will be fused and a temporal filter will be applied to clean the data. Next, ancillary data sets (e.g. other Copernicus global land service biophysical products) will be included and a supervised classification using Support Vector Machine techniques will be applied. Finally, at a third level, we will build upon the success of previous global mapping efforts and focus on the improvement in areas where the thematic accuracy of the respective maps was insufficient and working with probabilities to perform the final classification of each pixel. The proposed global land cover map uses a hierarchical legend based on the United Nations and Cover Classification System (LCCS). Compatibility with existing global land cover products is hereby taken into account. Training and validation data will be collected from multiple sources, among others by using existing reference datasets (e.g. GOFC-GOLD) and by running a crowdsourcing campaign through Geo-wiki. A first map covering continental Africa for the year 2015, with a first dynamic update for the year 2016 is targeted to become available early 2017.

## P3.2: Functional indicators in Southern Ecuador

**Brenner Silva**

The tropical mountain forest in the Andes of Southern Ecuador is a biodiversity hotspot, including dry and extreme humid conditions and the altitudinal range of thousands of meters. Within the scope of a research platform and after more than ten-years in this research area (mostly in the valley of the San Francisco River), we have focused on the retrieval of structural and spectral products by remote sensing to develop functional indicators (e.g. water regulation) using remote sensing at two spatial scales: crown and landscape. Airborne laser scanning, hyperspectral scanning, and operational satellites are used together with methods like individual tree-crown detection and simultaneous water flux measurements at leaf, tree, and landscape scales. Calibration and validation of the functional indicators have shown high potential as indicators of water use, forest composition and birds diversity in the tropical mountain. Current state of knowledge gained and concepts used are presented for discussion. It is suggested that, for the tropical mountain, remote sensing should consider not only sensor and terrain limitations, but also the link between individual and area-wide levels.

## P3.3: Rewilding in the steppes of Kazakhstan

**Matthias Baumann[1];** Johannes Kamp[2]; Benjamin Bleyhl[3]; Alexander V. Prishchepov[4]; Roland Kraemer[5]; Tobias Kuemmerle[3]
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Human pressure on natural ecosystems is increasing in most regions in the world, with generally negative outcomes for biodiversity. But human pressure is also decreasing in some regions, when farmlands are being abandoned and migration results in rural population declines. As a result, former intensively managed and now abandoned areas may provide opportunities for rewilding. One particular region that experienced substantial cropland abandonment and rural population decrease are the Eurasian steppe regions. During Soviet times, much land was used as cropland, but following the dissolution of the Soviet Union in 1991 a large proportion of cropland got abandoned. In addition, livestock numbers fell and rural population decreased, overall resulting in a decreased human pressure. Thus the region may provide new areas for wilderness that for example may further increase the ecological value of protected areas by increasing the connectivity among them. Our goal was to identify such areas in the Kostanay province (200,500 km²) in northern Kazakhstan, where cropland abandonment was widespread after 1991. Using Landsat image composites, we mapped cropland abandonment, and combined this with secondary statistics and found that extensive cropland abandonment between 1990 and 2000 (~7,400 km² = 36%), declining livestock numbers (-70%), and decreased human population density led to an effective rewilding of the Kazakh steppe, with rewilding areas increasing the effective area of and connectivity among protected areas. However, our results also show trends of re-cultivation of abandoned croplands since 2000 and subsequent decreases in wilderness between protected areas, suggesting that the window of opportunity for broad-scale conservation planning may close. Using the Landsat composites we were able to re-construct land-use history and by utilizing derived maps for a connectivity analysis we identified areas of conservation priority, highlighting the value of large-scale satellite imagery analyses in conservation planning and habitat monitoring.

## P3.4: Detecting the spread of invasive tree species in central Chile with combined Landsat and Sentinel-2 data

**Michael Förster[1];** Tobias Schmidt[2]; Prof Birgit Kleinschmit[3]; Fabian Ewald Fassnacht[4]; Julián Cabezas[5]
[1] TU Berlin; [2] Technical University Berlin; [3] Technical University of Berlin; [4] KIT - Karlsruhe Institute of Technology; [5] Karlsruher Institut für Technologie (KIT)

Chile has a large number of endemic species due to its isolated location and is therefore one of the biodiversity hots-spots of the Planet. At the same time a number of invasive species occurred over the last years and have shown to have a notable negative effect on Chilean ecosystems. Between 2016 and 2018, the project SaMovar (Satellite-based Monitoring of invasive species in central-Chile) will investigate the past and recent spread of selected invasive species.

The project will investigate the past and recent spread of selected invasive species. More specific, the objective is to map the current state of spread of three invasive species (Ulex europaeus, Acacia dealbata , Pinus radiata) suspected to have a large impact on local and regional biodiversity. Moreover, the future spread of the invasive species will be spatially estimated to produce risk maps for management measures. For both objectives the application of multi- temporal and multi-sensor satellite data, especially Sentinel-2 and the Landsat archive, will be pursued.

In a first step, the most recent distribution ranges of the three target species are detected using Sentinel-2 data. Because of the high temporal resolution, the different phenological phases of the species can be considered in the classification process. With the McNemar test it will be assessed which combination of acquisition dates is leading to the result with the significantly highest accuracy of a one-class classifier. The outcome of these optimal acquisition dates will be used in a second step to compare the classification results of Landsat and Sentinel-2 for 2016. Finally, the information on the classification quality of the different acquisition dates can be used as a weighting factor to classify the distribution of the invasive species from the 1980ies.

Together with the disturbance history of the region this information will be used as an input layer to species distribution models which will be developed to model the future spread of Pinus radiata, Ulex europaeus and Acacia dealbata assuming different climate scenarios. The outcome can provide methods to support the provision of "Essential Biodiversity Variables" defined by GEO BON.

## P3.5: Attribution of forest disturbance agents and recovery condition in the Bago Mountains, Myanmar

**Tetsuji Ota;** Katsuto Shimizu; Zar Chi Win; Nobuya Mizoue; Shigejiro Yoshida

Having accurate knowledge on forest disturbances and recovery is an important aspect for understanding current and future forest condition. Since different direct causes of disturbances make different impacts to subsequent forest recovery and structure understanding agents of forest disturbances is essential as well as quantifying areas affected by forest disturbances. In the context of increasing capacities of forest monitoring with remote sensing in the last decade, time series satellite data comprising temporally dense satellite images over vast area can provide comprehensive understanding of historical forest changes. This study investigated an approach to attribute disturbance and recovery both for small- and large-scale disturbances in tropical seasonal forests in Myanmar using remote sensing technology. We selected the total of 126 Level 1 Terrain corrected Landsat TM, ETM+ and OLI images located on five path/row of World Reference System 2. First, LandTrendr, which is a trajectory-based temporal segmentation and fitting algorithm, was performed to detect disturbance and recovery pixels. Detected disturbance and recovery pixels were then aggregated to patch-based change units. For each patch, we derived 29 predictor variables, including topographic, disturbance, recovery, pre-disturbance, post-disturbance and shape variables. Finally, change units were attributed to disturbance agents and recovery using predictor variables with Random Forest model. For implementing Random Forest model, we collected 1480 sample patches with random selection and conducted manual interpretation of disturbance agents. The pixel-based accuracy assessment for change detection showed that omission and commission errors of “Change” were 12.0% and 40.0%, respectively. On the other hand, omission and commission errors of “No Change” were 19.1% and 4.6%, respectively. The agents of omitted disturbances identified by human interpretation were 10 stand replacing disturbances caused by logging operation and one urban expansion caused by agricultural expansion. The patch-based Random Forest model for disturbance agent attribution achieved the overall accuracy of 85.1% and Kappa coefficient of 0.81. When considering areas of disturbance, 94.6% of the total area of test data were attributed to correct disturbance agents. The models could map widely distributed both small- and large-scale disturbances in the study area. The approach described here can be used for large area mapping of forest disturbances and recovery, and those information will provide useful information to analyze further condition of forests.

## P3.6: Remote sensing of scale dependent functional diversity in a temperate forest

**Carla Guillen Escriba[1];** Fabian D. Schneider[1]; Felix Morsdorf[1]; Andrew Tedder[1]; Eri Yamasaki[2]; Kentaro Shimizu[1]; Bernhard Schmid[1]; Michael E. Schaepman[1]
[1] University of Zurich; [2] Evolutionary and Ecological Genomics

Successful monitoring of forest biodiversity requires measurements of the complexity and diversity of life at different biological scales of organization (NRC 1999b). Different biodiversity metrics such as the functional diversity of plants proposed by Violle et al. (2007) sought to complement species composition-based approaches, by quantifying diversity not only by the species taxonomic value but also by their functional role. Different studies have found evidence of the direct influence that functional diversity between and within a community has on its functioning and provision of services (Díaz and Cabido 2001; Cardinale et al. 2012). Furthermore, functional diversity is strongly linked with the phylogenetic and taxonomic structure of a community

(Petchey and Gaston, 2002a; Flynn et al. 2011; Cadotte et al. 2009), and can be affected by abiotic stress and disturbance (Fortunel et al. 2014; Lebrija-Trejos et al. 2010) and biotic processes such as intra- and interspecific competition and dispersal (Takenaka et al. 1997; Gross et al. 2009). To understand how these interactions respond under environmental pressure, detailed observations are needed. At the same time, all of the above processes occur simultaneously and therefore overlap at different spatial and temporal scales (Biswas et al. 2015). Traditional in-situ approaches have provided very useful information, but are usually spatially constrained (Duro et al. 2007), hence exhibit limited possibilities to be extrapolated to larger scales (Pereira et al. 2013). With the advent of emerging remote sensing methods for functional traits mapping at regional to global scales, the gap of missing trait distribution at larger scales is to be filled (Jetz et al., 2016). In addition, increasingly remote sensing derived products are proposed to systematically assess large scale changes of biodiversity (Skidmore et al., 2015) and categorized into Essential Biodiversity Variables (EBVs) (Pettorelli et al., 2016). We propose to contribute to filling this gap at regional scale by using different remote sensing methods to derive EBVs in combination with in-situ sampling at different spatial and temporal scales.
We investigate the relevance of remotely sensed derived local interspecific trait variation to differentiate species at distant and close phylogenetic distances. We also quantify intraspecific trait variation using different structural and chemical functional traits, and detect trait responses along environmental gradients to attribute sources of functional diversity within species.
The test site is a mixed temperate forest located on the south-facing slope of the Laegern mountain, Switzerland. The intensive sampling area consists in a 9-hectare plot (47°28'N, 8°21'E) located on steep hills (with slopes up to 60°). Dominant species are European beech (Fagus sylvatica) and Ash (Fraxinus excelsior).
We perform phylogenetic analysis and retrieve architectural and biochemical plant traits (such as PAI, Canopy height, foliage height diversity, relative pigment content, LWC and more), from individual trees by using imaging spectroscopy as well as airborne and terrestrial laser scanning data, together with in-situ sampling schemes in a permanent forest research site.
To assess local-scale phylogenetic diversity, phylogenetic signals are quantified using the remote sensing data, resulting in spatial phylogenetic organization of different functional traits. Abiotic sources of intraspecific trait variation are quantified by using different environmental data.
We discuss the usefulness of combined remote sensing and in-situ sampling to bridge diversity scales from species to community level.

## P3.7: Retrieval of essential biodiversity variables-plant traits from SPOT 5 imagery

**Roshanak Darvishzadeh[1];** Andrew Skidmore; Tiejun Wang; Brian O'Connor; Anton Vrieling; PhD Chris McOwen; Dr Marc Paganini
[1] University of Twente

Mapping and monitoring plant traits recognized as Essential Biodiversity Variables (EBVs) are not only useful for biodiversity assessment but for a variety of other applications including agricultural, ecological, and meteorological studies. Many of these variables are utilized in models quantifying the exchange of energy and matter between the land surface and the atmosphere. Among these variables leaf chlorophyll and nitrogen are of prime importance as they are highly correlated with many other pigments in plants and affect the developments of biophysical variables such as leaf area. Multispectral sensors, especially the upcoming Sentinel-2 with high spatial resolutions have provided ample opportunities for estimating these parameters. In this study, the retrieval of chlorophyll and nitrogen is investigated utilizing SPOT 5 images and Radiative Transfer Model (RTM). Several SPOT5 images were acquired between March and September 2015, for the National Park of Schiermonnikoog in the north of the Netherlands. In situ measurements of a large number of traits including chlorophyll and nitrogen were collected concomitant with the time of image acquisitions. The widely used canopy radiative transfer models: PROSAIL (SAILH and the PROSPECT) were investigated for retrieval of chlorophyll and nitrogen in the study site. A large look-up table was generated accounting for available prior information related to the distribution and range of the vegetation characteristics of the study site. The LUT was then inverted using the spectral reflectance obtained from the images. To assess the performance of the model inversion and analyze the suitability of the model, the normalized RMSE and R2 between independent in situ measurements and estimated parameters were used. Our results have demonstrated the potential and drawbacks of model inversion for estimating essential biodiversity variables at wetlands using multispectral satellite data.

## Species Distributions

### P4.1: How to predict fine resolution occupancy from coarse resolution atlas data

**Quentin Groom[1];** Yoni Gavish[2]; Charles J. Marsh[2]
[1] Botanic Garden Meise; [2] University of Leeds

Biodiversity distribution data are often collected as presences or absences within regular grids. These studies are conducted at a wide variety of grain sizes, but grid squares of 1 km2, 4 km2, 25 km2 and 100 km2 are common. One of the most commonly used summary statistics of such maps is the area of occupancy (AoO). However, AoO is highly scale-dependent and increases with the resolution. To compare studies conducted at different resolutions one could reduce fine resolution data to the coarsest, however it would be more desirable to predict fine resolution occupancy from the coarsest. Furthermore, a standardized AoO is useful when assigning the conservation status to threatened species. The prediction of fine resolution occupancy is called “downscaling” and at least ten different algorithms have been proposed. However, there are few guidelines on which methods are the most reliable and under which circumstances. For example, which methods are most suitable for particular taxa and how does the prevalence of the organism influence downscaling. As part of the EU-BON project, we have studied downscaling methods using data on hundreds of vascular plant and bird species. We have also used a variety of natural and anthropogenic landscapes in our analysis. From these results we have formulated recommendations for downscaling methods.

### P4.2: Relating the disturbance history of natural vegetation in central Chile with the spread of three invasive species

**Fabian Ewald Fassnacht[1];** Julián Cabezas[2]; Tobias Schmidt[3]; Michael Foerster[4]; Birgit Kleinschmit[4]
[1] KIT - Karlsruhe Institute of Technology; [2] Karlsruher Institut für Technologie (KIT); [3] Technical University Berlin; [4] Technical University of Berlin

Chile has a large number of endemic species due to its isolated location and is therefore one of the biodiversity hots-spots of the Planet. At the same time a number of invasive species occurred over the last years and have shown to have a notable negative effect on Chilean ecosystems. Between 2016 and 2018, the project SaMovar will investigate the past and recent spread of selected invasive species.
One focus within the project will be the reconstruction of the disturbance history of natural vegetation areas of three administrational regions in central Chile (Maule, Biobio, Isla Chiloe). The targeted time-period for the analysis will be 1985-2016. Based on time-series analysis using Landsat, MODIS and Copernicus data as well as recent and historic reference information, disturbance occurrences and the type of disturbance will be recorded. The mapping of disturbances will base on the creation of a vegetation mask followed by disturbance mapping based on LandTrendr and BFAST. After the mapping of the disturbances, each disturbed area will be assigned to one of the most common disturbance agents in the study areas. These include fire, clear-cutting and biotic agents. Methodically, the assignment to disturbance agents will base on the analysis of the reflectance signal and the shape of the disturbed area. The development of the signal over the first few years after the disturbance will also be considered as additional information.
The disturbance history will subsequently be used as one input layer to species distribution models which will be developed to model the future spread of Pinus radiata, Ulex europaeus and Acacia dealbata assuming different climate scenarios. These three non-native woody species have been observed to have a prominent impact on the natural vegetation of central Chile by invading non-managed areas, that often suffered from disturbances briefly before the invasion.
The project thereby methodically targets on 1) the adaptation of the methodical state-of-the-art in remote sensing based mapping of invasive species to the new data delivered by Copernicus and 2) thereby provide methods to support the provision of "Essential Biodiversity Variables" defined by GEO BON. The scientific interest mainly lies in an increased understanding of the invasion dynamics of the three target species in a highly heterogeneous landscape that has undergone drastic land-use changes over the last few decades.

## P4.3: Long-term changes in plant species diversity as related to climatic variations at the Sandveld observatory, Namibia

**Emma Shidolo;** Ben Strohbach
Namibia University of Science and Technology

The Kalahari landscape has been described as especially vulnerable to global climate change, with wide-spread re-mobilisation of dune fields being predicted over the next 50 to 80 years. The Sandveld Biodiversity Observatory is situated in the central Kalahari in Namibia. The climate is semi-arid, with typical high variability in seasonal rainfall.
Through regular monitoring over the past ten years we can show that the plant species diversity

and plant cover of the vegetation is responding closely to the amount of rainfall during the particular, as well as the previous, seasons. As the area is considered being one of the prime beef producing farming areas in Namibia, these results are important in the justification of conservative stocking rates, in order to utilise the grazing resource sustainably over the long-term.

## Data Standards

### P5.1: Mapping the global biodiversity informatics landscape

**Heather Bingham;** Katherine Despot Belmonte; Lauren Weatherdon; Corinne Martin

As data on the natural world becomes more complex and more abundant, the challenges of collating, analysing, visualising and sharing them are becoming greater. Biodiversity informatics applies information technology techniques to tackle these challenges, and develops systems that allow data to be stored, accessed and combined in ways that optimally serve the international community. Biodiversity informatics projects increasingly integrate datasets from disciplines beyond biodiversity, such as those derived from climate, natural capital, ecosystem services, and socio-economic research, to create informatics products that are far broader in scope. There are many biodiversity informatics projects, datasets/databases and initiatives at the global level, and many more at regional, national, and sometimes local levels. Based on a high-level, non-exhaustive review of the global projects, datasets/databases and initiatives, we present a global map of the biodiversity informatics landscape and its main components. This is a first attempt at identifying the key players and mapping them in a way that depicts their roles, missions, and interconnectedness, where relevant. The GEO BON conference (Leipzig, 2016) will be a unique opportunity to present this map to an informed audience, and gain feedback on missing components and connections between them. Beyond a simple descriptive approach of the existing landscape, this map will support a better understanding of the landscape's current functioning, so that the key players can better work together and use the best of what we already have.

## Development of Biodiversity Observation Networks - National BONs & tools for BON development

### P6.1: The importance of capacity building for the development of integrated and interoperable biodiversity observation networks

**Larissa Smirnova[1];** Kim Jacobsen[1]; Patricia Mergen[2]; Hannu Saarenmaa[3]; Anke Hoffmann[4]
[1] Royal Museum for Central Africa; [2] Botanic Garden Meise; [3] University of Eastern Finland; [4] Museum für Naturkunde Berlin

The fragmentation and heterogeneity of biodiversity information networks is challenging. On the one hand, biodiversity datasets represent a diverse array of biological species and ecosystems. This data is collected using a variety of sampling methodologies, each impacting the

parameters that are used to model population trends. On the other hand, important knowledge gaps remain, which are related to temporal, geographic and taxonomic coverage. Policy makers rely on the availability of clear and practical biodiversity information. The identification of threatened species or localities demands harmonized and comprehensive data sets.
GEO BON and similar projects foster the development of information architecture robust enough to incorporate such diverse data. EU BON has developed an effective registry system building on major resources such as GBIF, LTER, Lifewatch, DataOne, EuMon, etc., and linking them using the GEOSS Data Access Broker system. This compatible architecture is supported by data sharing and publishing tools and web service interfaces. Adoption of the outputs is promoted through a helpdesk and a comprehensive training program. This capacity building of biodiversity communities (e.g. researchers, citizen scientists, non-governmental organisations) who are involved in collection, monitoring and dissemination of biodiversity information covers different aspects of data sharing and publishing. Some topics are a more general introduction to the data publishing landscape, while other topics are more hands-on exercises on data publishing using different EU BON supported tools (GBIF IPT, PlutoF workbench, Pensoft Arpha tool and Plazi's TreatmentBank and GoldenGate). Attention is given to different types of biodiversity data (e.g. species occurrences, sample-based and citizen science data) and how to register these in GEOSS. Also an introduction to EU BON architecture and features of the EU BON portal are briefly highlighted during the workshops.
These training modules are of particular interest as promotion tools, to stimulate data mobilization, address knowledge gaps and contribute to the development of biodiversity modeling initiatives in the EU and beyond. To date, 4 training workshops have been held in various locations throughout Europe, and one outside Europe (Madagascar) in collaboration with GBIF. Over 100 participants were trained, coming from 34 different countries. Up to 8 experts are present during each workshop to deliver state-of-the-art practical knowledge and hands-on experience in the use of data sharing, modelling and publishing tools. This capacity building will enable a more stable and durable information architecture, as data providers are familiarized with the most recent standards and applications available.

## P6.2: Capacity development in DR Congo with a focus on biodiversity

**Luc Janssens de Bisthoven[1];** François Muhashy Habiyaremye[1]; Marie-Lucie Susini[1]; Han De Koeijer[1]; Maarten Vanhove[1]; Anne-Julie Rochette[1]; Anne Laudisoit[2]; Erik Verheyen[1]
[1] Royal Belgian Institute of Natural Sciences; [2] University of Antwerp / University of Liverpool / Université de Kisangani

The Belgian Directorate for development cooperation (DGD) started in 1999 to support the Royal Belgian Institute of Natural Sciences (RBINS) for developing a capacity building programme focused on biodiversity, called 'CEBioS' or 'capacities for Biodiversity and Sustainable development'. It grew from 125 K€ to more than 1,2 K€ anno 2016. The interventions in the partner countries of the Belgian Development Cooperation consist of (1) individual "Global Taxonomy Initiative" (GTI) grants, (2) local field work and workshops, (2) capacity development on the Clearing House Mechanism (CHM) as information tool in the framework of the Convention for Biological Diversity (CBD), (3) raising awareness, (4) diverse initiatives concerning policy, (5) Monitoring, Reporting and Verification (MRV) and (6) capacity building about the Nagoya protocol on Access and Benefit Sharing (ABS) of genetic resources.

The programme is run by a staff of ± 10 persons based at RBINS, Brussels, which has also the mandate for the national focal points for e.g. CBD, the Global taxonomy Initiative (GTI) and the CHM. The activities of the programme are carried out in close cooperation with the Royal Museum of Central Africa (RMCA) and the Botanic Garden Meise. An important aspect of the programme is the institutional strengthening of partner institutes in Burundi, DRCongo, Benin, Peru and Vietnam.
Concerning DRCongo, the programme cooperates with the 'Institut Congolais de Conservation de la Nature' (ICCN), the University of Kisangani (UNIKIS), the 'Centre de la Surveillance de la Biodiversité' (CSB) and other major academic institutions. The cooperation with ICCN as main partner consists of training and implementation of habitat monitoring, with a focus on the study of the vegetation cover and ecosystem dynamics, e.g. medicinal plants or mushrooms, of selected protected areas (e.g. Itombwe reserve, Luswishi reserve, Virunga N.P., P.N. des Mangroves, Kahuzi-Biega N.P.), the monitoring of temporal changes by rangers, and the production of lexica in order to document and support this kind of field work, covering ecosystem services from pluvial rain forest and dry forest. Several trainings are given to the DR Congo national CHM focal point and a network of provincial antennae in order to better harness and disseminate useful information on biodiversity through the internet in the framework of CBD. Public awareness activities on the importance to conserve and sustainably use the biodiversity have been undertaken with e.g. (i) the NGO "Biodiversité au Katanga" in Lubumbashi and the villages surrounding the Upemba National Park, or (ii) a cooperation between the ministries of education and environment supported by the Belgian educational actor VVOB. RBINS also provides access to historical photographical archives of the National Parks of Congo, which generated inputs to several high quality books. Finally, each year a number of researchers from e.g. UNIKIS and CSB gets training on taxonomy, ecology and genetics on e.g. fish, reptiles, insects (e.g. edible caterpillars), edible lianas and mushrooms with special attention to their sustainable use as ecosystem services to the local communities.

## P6.3: Restauration and Functional Diversity monitoring protocols

**Maria Londono[1];** Hernando Garcia; Beatriz Salgado; Wilson Ramirez; Mauricio Aguilar; Nicolas Urbina-Cardona
[1] Humboldt Institute

Humboldt Institute in partnership with Colombian research institutions published in 2015 two innovative books with specific protocols and tools for Monitoring Restoration Processes and measuring Functional Diversity, we aim to present these books as they are important tools for building robust biodiversity observation systems in thematic areas in which these types of protocols are not very usual.

"La ecología funcional como aproximación al estudio, manejo y conservación de la biodiversidad: protocolos y aplicaciones" is a book written by 19 authors from 10 different institutions, this book describes in a rigorous way the scientific methodologies and the ecological role of functional traits in four taxonomic groups (plants, birds, amphibian and fishes).

"Monitoreo a procesos de restauración ecológica" is a book were a conceptual frameworks for restauration processes are developed and tools for assessment of the process are describe. You can find criteria, indicators and quantitative validators for assessing biological, economic and social aspects of restauration.

## P6.4: Data sharing tools for Biodiversity Observation Networks

**Larissa Smirnova[1];** Patricia Mergen[1]; Quentin Groom[2]; Hannu Saarenmaa[3]; Pavel Stoev[4]; Lyubomir Penev[4]; Israel Peer[5]; Veljo Runnel[6]; Antonio Garcia Camacho[7]; Donat Agosti[8]; Aaike De Wever[9]; Timothy Vincent[10]; Christos Arvanitidis[11]
[1] Royal Museum for Central Africa; [2] Botanic Garden Meise; [3] University of Eastern Finland; [4] Pensoft Publishers & Bulgarian Academy of Sciences; [5] GlueCAD; [6] University of Tartu; [7] CSIC, Spanish Council for Scientific Research; [8] Plazi; [9] Royal Belgian Institute of Natural Sciences; [10] INPA - National Institute for Amazonian Research; [11] Hellenic Centre for Marine Research

It has been the policy of the EU BON project that it is better to promote and continue development of preexisting tools, rather than creating new one. This approach limits the fragmentation of the infrastructural environment and leverages former investments in software and training.
The recent study done by the EU BON project on available data sharing and data publishing tools used in the natural history domain, resulted in comprehensive report D2.2 which will be published soon in RIO journal.
This is done from the perspective of the needs of the biodiversity observation community with an eye on the development of a unified user interface to these data – the European Biodiversity Portal (EBP).
About 30 data sharing tools have been evaluated and the results of these assessments are presented in the report and is also available online. To fully meet the objectives of the project on data mobilization and integration and to meet the user requirements for different types of data, a combination of tools have been selected for deployment. Here we provide a short overview of their specifications; the adaptations that have been made and results of the testing. These are followed by recommendations on the implementation of the tool in a working environment.
GBIF IPT: To publish and share biodiversity data sets and metadata through the GBIF network. It allows publication of three types of biodiversity data: i) primary occurrence data (specimens and observations); ii) species checklists and taxonomies; iii) sample-based data from monitoring programs.
Spreadsheet tools: 1) GBIF Spreadsheet processor is a web application that supports publication of biodiversity data to the GBIF network using pre-configured Microsoft Excel spreadsheet templates; 2) DataUp tool is the tool developed by DataOne to help environmental scientists to upload files to a repository for data management.
The ARPHA Publishing Platform: Narrative (text) and data integrated publishing workflow to mobilize, review, publish, store, disseminate, make interoperable, collate and re-use data through the act of scholarly publishing. Three types of biodiversity data are supported: i) primary occurrence data (specimens, observations), ii) species checklists and taxonomies, iii) sample-based data from monitoring programs.
TreatmentBank: A platform to store, annotate, access and distribute taxonomic treatments and the data objects within them. It works with GoldenGate and XML schemas TaxonX and TaxPub, which are tools to convert unstructured text into semantically enhanced documents with an emphasis on taxonomic data such as treatments, scientific names, material observation, traits and bibliographic references.

Metacat and Morpho: Metacat is a repository that helps scientists store metadata and data, search, understand and effectively use the data sets they manage or those created by others. A data provider using Metacat can become a DataONE member node with a relatively simple configuration. Morpho is an application designed to facilitate the creation of metadata.
PlutoF API1: An online service to create, record, manage, share, analyze and mobilize biodiversity data. Data types include ecology, taxonomy, metagenomics, nature conservation and natural history collections.

## P6.5: Monitoring in Angola

Fernanda Lages

Angola is country of 1,2 million sq. km, situated on the west coast of Africa with a rich biodiversity, with ecosystems ranging from the desert of the Namib to the rainforests of Cabinda and to the vast wetlands of the upper Zambezi, Congo, Okavango and Cunene headwaters. Extensive miombo woodlands occupy 60% of the country, dominating the interior plateau at between 1000 to 2000 m altitude. Montane grasslands and relic Afro-montane forests occur along the endemic-rich escarpment and on the central highlands over 2000 m. After a protracted civil war for more of 20 years that disrupted the economic and social structure of the country, biodiversity conservation has not been a priority and is poorly documented. Additionally, one of the many long-term institutional impacts of the war has been the gradual loss of the capacity to conduct research, since the national universities failed to form a body of researchers qualified to conduct biodiversity studies or environmental monitoring. At the present time there is an effort to overcome the theoretical and methodological difficulties that led to low knowledge on biodiversity in Angola, its threats and changing trends. The country's accession to the SASSCAL initiative, the Southern African Science Service Centre for Climate Change and Adaptive Land Management, provided an unique opportunity for both establish a network of individuals and organizations able to assess and continuously monitor the country's natural resources and integrate the regional network of biodiversity observatories. Since 2013 five standardized biodiversity observatories were established in the southwest region of the country: Tundavala (Huíla, Angolan Montane Forest Grassland Mosaic), Candelela (Cuando-Cubango, Zambezian Baikiaea Woodlands), Bicuar National Park (Huíla, Angolan Miombo Woodlands), Cussseque (Bié, Angolan Miombo Woodlands) and Espinheira at Iona National Park (Namibe, Kaokeveld desert). This presentation will be focusing on the first results of the monitoring activities that started 3 years ago, and on the opportunities for expansion of the observatories to the northern region of the country.

## P6.6: The potential use of UAV's to monitor vegetation at long-term observatories in Namibia

**Ben Strohbach;** Leena Naftal
UAV's, specifically miniature surveying drones, are becoming increasingly popular for high-resolution, easily repeatable aerial photography for biodiversity monitoring purposes. Such a drone was recently obtained for exactly this purpose - to aid the monitoring of the woody vegetation at the biodiversity observatories in Namibia. The biodiversity observatories in Namibia however do not only cover woodland or savanna vegetation - in the contrary, several are situated in both

dwarf shrub savanna (with the dominating woody vegetation below 1 m height) as well as desert biomes, including the Namib lichen fields.
Initial trials indicate that the monitoring of the woody vegetation is easily achieved, with the necessary ground-truthing. Next to the classification of orthomosaics into species' distribution maps (to aid the monitoring of the woody vegetation), the images can also be used to determine the tree/grass/bare ground ratios (important in the determination of potential grazing capacity in an area), as well as detailed surface modelling. This, in turn, is important to determine volumes of tree and shrub species, which in turn can be used to determine woody biomass. The DSM's will also have important applications in the monitoring of erosion at long-term observation sites.
Tests are ongoing, including the use of various cameras (RGB vs NIR, possibly also the use of red-edge and/or thermal cameras) as well as the surveying at various altitudes and thus different ground resolutions, varying between 2 cm and 10 cm ground resolution.

## P6.7: The role of Belgian and African Natural History Institutions in biodiversity-related capacity building in Africa

**Patricia Mergen[1];** Hans Beeckman[2]; Francesca Lanata[3]; Steven Dessein[3]; Maarten Vanhove[4]; Anne-Julie Rochette[4]; Luc Janssens de Bisthoven[4]
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Belgium has kept close ties with Africa, mainly Sub-Saharan Africa, in terms of collaborative activities. Historically to nowadays a vast amount of very valuable data and knowledge has been accumulated about species occurrences and associated habitat parameters in the Belgian and African scientific institutions going in pair with the vast collections they harbor. Recently developed standards and applications enable to make this information accessible in a re-usable manner for the exploitation of trait-based ecology for inclusion into predictive modelling and species distribution algorithms of inestimable value for Climate change, biodiversity or habitat loss studies. For example the Earth observation program of Belgium, with its dedicated ProbaVegetation Satellite has a large part of its remote sensing studies focusing on the African continent. Capacity building in all its aspects and targeting different audiences, plays a very important role for the proper understanding and valorization of the vast amount of knowledge available and has a real impact both on societal challenges at stake and on guaranteeing scientific excellence. In this regard natural history institutions like Botanic Garden Meise (BGM), Royal Museum for Central Africa (RMCA) and Royal Belgian Institution of Natural Sciences (RBINS) have set up a long term and stable knowledge and competences exchange network with their African partners. The subjects and audiences reached out are vast and multidisciplinary, ranging from fundamental sciences such as classical taxonomy and morphological studies, to best practices for sampling campaigns or collections management. Modern biodiversity information standards and applications adapted for monitoring sites are included, as well as the use of recent molecular approaches. Aspects like policymaking and legislation, handling of copyrights and Access and Benefit Sharing are an integral part of the programs. The recently adopted Nagoya Protocol is here particularly challenging, as there are still needs in terms of awareness and clarifications on practical implementation of the new regulations.

This poster will illustrate how the three institutions implemented various capacity building programs. They concern both academic and non-academic trainings, courses of various duration held either in Africa or in Belgium, supervision of master and PhD theses, individual or group tutorials, production of training material, joint publications or support in fund raising endeavors. One can cite here the RMCA's three months course in wood biology and forest research both in Congo and in the laboratory or the initiative funded by the Belgian Cooperation Central African Biodiversity Information Network (CABIN), offering individualized tutorials to provide African biodiversity related data to the Global Biodiversity Information Facility, including using the newly developed Sample Based Data Integrated Publishing tool and standards extensions in collaboration with EU BON. BGM is particularly active in on the job training of both the scientific and technical staff in Central African major botanic gardens and herbaria such as Kisantu or Yangambi in the D.R. Congo. Topics concern the restauration, management and digitalization of the collections and infrastructures. Goals are also to maintain the local competences in taxonomic descriptions of the Central African Flora at international high standards. Environmental education and involvement of the local populations and policymakers are addressed.

The three institutions are very active in terms of Capacity building and monitoring biodiversity in the UNESCO Man and Biosphere Reserves of D.R. Congo. There is a partnership with the Congo Wildlife Department (ICCN) for environmental education and raising awareness about plants and ecosystems vulnerability, where working with the local population, the civil society, the media and policy makers is a priority. Further such partnerships exist with other major key institutions in D.R. Congo, such as the INERA (Institut National pour l'Etude et la Recherche Agronomiques ), ERAIFT (École Régionale Post Universitaire d'Aménagement et de Gestion Intégrés des Forêts et Territoires Tropicaux), UNIKIN (University of Kinshasa), UNIKIS (University of Kisangani) or the Virunga foundation.

Other activities concern the conservation fungi with programs addressing conservation though valorization and local commercial outputs for sustainability of the local populations. Similar approaches are used for preserving the local flora both in and ex situ in the Virunga region including production of ornamental plants or addressing food security aspects via implantation of vegetable gardens. Last but not least the programs also tackle with conservation and sustainable exploitation of species with high commercial potential such as banana, coffee or cacao.

While many of the activities occur in D.R. Congo, do the partners also have similar programs in other African countries such as Rwanda, Burundi, Gabon or Cameroon. There is a clear need to sustain this long term and stable capacity building network of experts and funding bodies to address the above mentioned challenges and provide excellent, meaningful and re-usable scientific outputs with a real impact of biodiversity and habitat conservation, as well as on the wellbeing of the local populations.

## P6.8: Land Grabbing of State Forest Area and Policy Implication for Application of Biodiversity Observation Network's Achievements in Indonesia

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Indonesia is one of countries which have the highest levels of biodiversity in the world. About 70% of the national territory of Indonesia is 'State Forest Area' (Kawasan Hutan). Therefore, a proper understanding of the state forest area is very important for application of biodiversity observation network's achievements in Indonesia. This study investigated the current situation of the state forest area through analysis of "Forestry Statistics of Indonesia", "Forest Utilization Data and Information", and the related laws.
The state forest area is defined as a specific territory designated by the government as permanent forests (Article 1, Law No. 41 in 1999 about Forestry) and classified into three categories: (1) 'Conservation Forest' (Hutan Konservasi) which has specific characteristic established for the purposes of conservation of animal and plant species and their ecosystem, (2) 'Protected Forest' (Hutan Lindung) which is designated to serve life support system, maintain hydrological system, prevent of flood, erosion control, seawater intrusion, and maintain soil fertility, and (3) 'Production Forest' (Hutan Produksi) which is designated mainly to promote sustainable forest production.
The conservation forest is further classified into three categories: (1) Sanctuary Reserve Area consisting of Strict Nature Reserve and Wildlife Sanctuary, (2) Nature Conservation Area consisting of National Park, Grand Forest Park, and Nature Recreation Park, and (3) Game Hunting Park. Similarly, the production forest is also further classified into three categories: (1) Limited Production Forest, (2) Permanent Production Forest, and (3) Convertible Production Forest. Convertible production forests are area which will be converted to other land use such as palm oil plantation.
Conservation forest is 16.2% (approximately 21 million ha), protected forest is 24.5% (approximately 32 million ha), and production forest is 59.3% (approximately 78 million ha) of total forest area. More than half of the state forest area is designated for production forest. A lot of convertible production forests are located in Papua province (about 9.3 million ha) and Riau province (about 4.8 million ha).

There are six types of Forest and Wood Products Utilization License (IUPHHK: Izin Usaha Pemanfaatan Hasil Hutan Kayu): (1) Logging Natural Forests (HA: Hutan Alam), (2) Industrial Tree Plantation (HTI: Hutan Tanaman Industri), (3) Ecosystem Restoration (RE: Restorasi Ekosistem), (4) Community Plantation (HTR: Hutan Tanaman Rakyat), (5) Community Forestry (HKm: Hutan Kemasyarakatan), (6) Village Forest (HD: Hutan Desa). Basically, the licenses are issued to production forests, whereas the licenses of HKm and HD are issued as both belong to protected forests. As of November 2012, 736 licenses (approximately 35 million ha) were issued, of which: (1) 296 were HA licenses (approximately 24 million ha); (2) 234 were HTI licenses (approximately 98 million ha); (3) five were RE licenses (approximately 0.2 million ha); (4) 112 were HTR licenses (approximately 0.7 million ha); (5) 50 were HKm licenses (approximately 0.19 million ha); and (6) 40 were HD licenses (approximately 80 thousand ha). HA licenses were 68.6% (approximately 24 million ha) and HTI licenses were 28.0% (approximately 10 million ha). Thus, HA and HTI licenses collectively accounted for 96.6% of the total licenses area. Almost all licenses areas were designated for HA and HTI licenses.
Seventy-nine percent of HA licenses (234 licenses) and 89.8% of HTI licenses (210 licenses) were for areas of less than one hundred thousand ha, but only 7.1% of HA licenses (21 licenses) and 3.8% of HTI licenses (nine licenses) were for areas of more than two hundred thousand ha. However, 7.1% of HA license holders for areas of more than two hundred thousand ha held 26.9% of the total area (about 6.5 million ha). Similarly, 3.8% of HTI license holders held 25.2% of the total area (about 2.5 million ha). Therefore, few companies held large-scale forest land.

Furthermore, 28.6% of total HA area (about 7.06 million ha) was accumulated by 10 company groups, and 39.0% of total HTI area (3.5 million ha) was accumulated by only two company groups.
Current situation of the state forest in Indonesia is as follows: (1) about 70% of Indonesian land is owned by the government as state forest area; (2) more than half of the state forest area is designated for production forest and almost all IUPHHK areas are designated for HA and HTI; and (3) many HA and HTI areas are held by few companies and further acquired by company groups. Therefore, it is necessary to consider the land grabbing of the state forest area when applying the achievements of biodiversity observation network for policymaking on biodiversity conservation in Indonesia.

## Development of Biodiversity Observation Networks - Thematic & Regional BONs

### P7.1: EU BON – Constructing the European Hub for GEO BON

**Anke Hoffmann;** Florian T. Wetzel; Johannes Penner; Katrin Vohland; Christoph L. Häuser

There is an urgent demand to integrate, harmonise and standardise biodiversity information from on-ground to remote sensing data, in order to adequately address questions from decision makers. EU BON, the European Biodiversity Observation Network (FP7 EU project, 2012–2017; www.eubon.eu), addresses the existing barriers and aims at improving the biodiversity data landscape. There are a number of different roles and contributions of Biodiversity Observation Networks (BONs) towards mobilising biodiversity information for use by policy development and decision-makers. At the center of the EU BON's efforts are the adoption and promotion of existing standards of good practices and integrating data within a single biodiversity portal in order to make them discoverable, accessible and easily digestible.

More specifically, EU BON aims to advance knowledge and management of biodiversity by building a European gateway for biodiversity information, which will integrate a wide range of biodiversity data and make it freely available for scientists, policy makers, and the public (Hoffmann et al., 2014). To achieve this aim, a large collaborative network has been assembled with contributions from 31 partners from 18 countries including leading research institutions, small companies, NGOs and many associated institutions.

The project integrates social networks of science and policy as well as technological networks, which results in numerous products, amongst others the above mentioned new open access portal for sharing biodiversity data and tools as well as results from state of the art analyses. The developed tools are evaluated and refined across terrestrial, marine and freshwater ecosystems in order to fill the previously identified knowledge and data gaps (Wetzel et al., 2015). A network of test sites is used to verify the observed patterns, processes and trends.

EU BON as the European regional BON contributes to GEO BON's work programme in different ways. EU BON is directly linked to several GEO BON working groups and delivers access to biodiversity data, data integration, and analysis that links to international environmental policies, but also provides technical solutions such as the spatial EBV browser, the Darwin core extension for sample-based monitoring and the GBIF IPT tool for publishing biodiversity data. It is planned that all analytical tools developed or advanced in EU BON will become part of the "BON-in-a-Box".

## P7.2: Capacity building for establishing biodiversity indicators in Africa

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Royal Belgian Institute of Natural Sciences

The CEBioS (Capacities for Biodiversity and Sustainable Development) team at the Royal Belgian Institute of Natural Sciences provides capacity building on biodiversity policy and research related to biodiversity, thereby promoting sustainable development in developing countries. Activities include research, training, mainstreaming of biodiversity in development cooperation, knowledge dissemination, awareness raising, and policy advice on the conservation, management and sustainable use of biodiversity in the South. The team is funded by the Belgian Directorate-general for Development Cooperation and Humanitarian Aid. Its activities are part of the implementation of the Aichi targets, the EU biodiversity strategy 2020 and the Belgian biodiversity strategy 2020.
This poster focuses on capacity building in Africa through specific activities: Publication of biodiversity information through the Clearing-House Mechanism (CHM) and the NBSAP cross-linking tool, archives of the former national parks of Belgian Congo, policy-relevant science, capacity building for taxonomic research through the Global Taxonomy Initiative, and a new call on Biodiversity indicators that will be presented in an oral presentation in the same session. The aim of the call is to strengthen the science-policy interface and to produce and translate biodiversity data suitable for the establishment of national biodiversity indicators and their use for national reporting.

www.geobon.org

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