Last Chance to See? What is the Role of SDI's in the Race to Halt Biodiversity Loss?

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Abstract

Attempts to stem the rate of biodiversity loss worldwide have so far failed to produce the desired outcomes. A new impetus to address this problem has been given at the culmination of the International Year of Biodiversity in 2010 with the Convention on Biodiversity (CBD) summit in Nagoya. Outcomes of the summit include a Strategic Plan for Biodiversity 2011-2020 and the Aichi Biodiversity Targets. Global initiatives such as these generate many challenges for data gathering, sharing, analysis and presentation, and highlight the need for concerted action, including in the domain of spatial information. Are existing SDI's providing the necessary data and technological platforms for the biodiversity community? The BIOPAMA (Biodiversity and Protected Areas Management) project, jointly run by the European Commission's Joint Research Centre and the International Union for Nature Conservation (IUCN), is addressing this question as it seeks to establish regional observatories for biodiversity information in the Africa, Caribbean, Pacific (ACP) region. BIOPAMA will be a pioneer opportunity to implement tools such as the Digital Observatory of Protected Areas (DOPA), which have been the outcome of recent JRC research projects. Much like the subject matter they deal with, the IT environments of initiatives such as BIOPAMA and DOPA are extremely diverse "ecosystems", with components that are highly interdependent on one another. Whilst the classic SDI paradigm does much to facilitate information exchange, and for which there are many operational examples, there is an ongoing need to rapidly develop high-performance, sophisticated architectures for distributed modeling and geo-processing, which is pushing the boundaries of SDI and biodiversity informatics research. We will illustrate this through examples of our work on biodiversity monitoring across the globe.

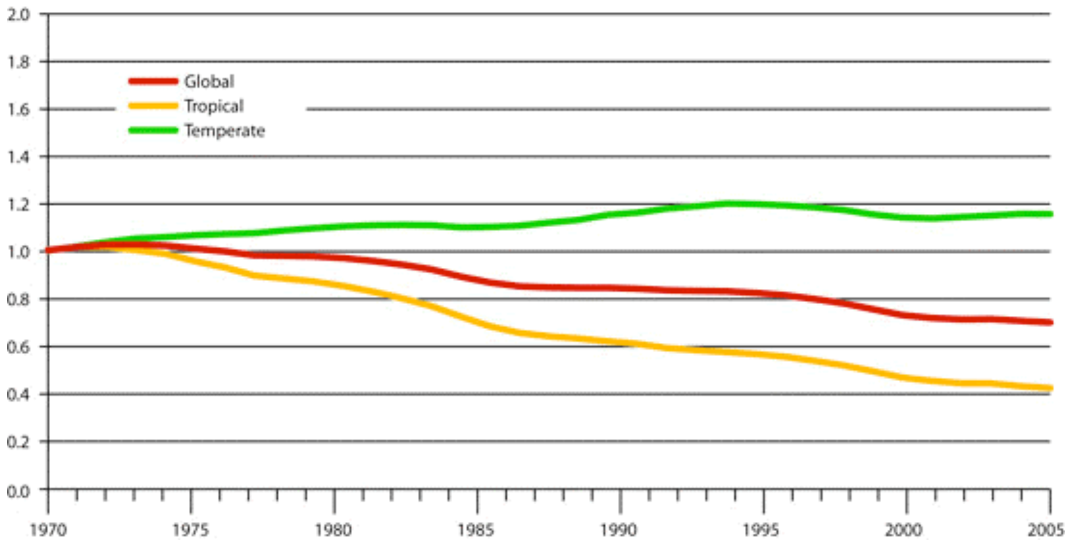
Keywords: ACP, Protected Areas, Biodiversity, DOPA, BIOPAMA, GEOBON

1 Current trends in biodiversity

In April 2002 the governments of countries that are party to the Convention on Biodiversity (CBD) agreed to achieve a significant reduction in the rate of biodiversity loss by 2010. This target was subsequently endorsed by the World Summit on Sustainable Development and the United Nations General Assembly and was incorporated as a new target under the Millennium Development Goals.

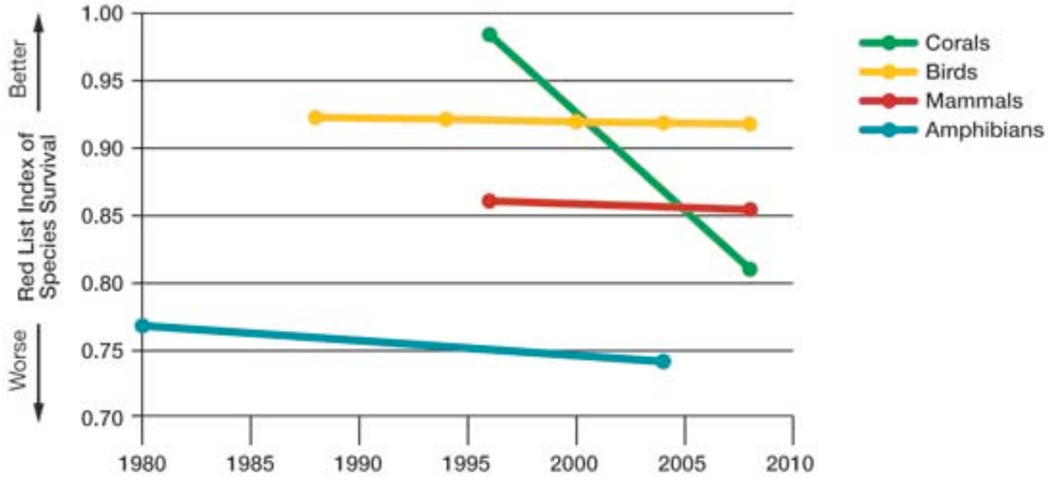
The third edition of the Global Biodiversity Outlook (GBO), published by the CBD in 2010, has concluded that this target has not been met. In fact, many of the drivers of biodiversity loss are accelerating (habitat loss, over-exploitation, climate change, pollution, alien invasive species). The Living Planet Index, developed by the World Wildlife Fund and UNEP-World Conservation Monitoring Centre, which tracks the status of over 2500 vertebrate species, has shown an overall 30% decline between 1970 and 2007 (WWF, 2010), with significant differences between tropical regions (-60%) and temperate (+29%) (Figure 1).

Figure 1 – The Living Planet Index, source WWF & Zoological Society of London



The Red List Index, calculated from the International Union for Conservation of Nature (IUCN) Red List of Threatened Species, measures the overall risk of extinction in sets of species and shows that all species groups with known trends are deteriorating in status (Figure 2).

Figure 2 - Red List Index of Species Survival - Source: Hilton-Taylor et al. (2009)



Analysis of the fossil record and comparison with well-documented extinctions of amphibians, mammals and birds over the last 100 years, have led to estimates that current documented rates of extinction are roughly 100 times higher than these background rates. Although based on numerous assumptions, and consequently controversial, modelled predictions are more than ten times higher than the current rate (Millenium Assessment, 2005).

To date, approximately 2 million species have been described, whereas estimates of the total number of species in existence range from 5-30 million (IUCN). Of the described species, less than 10% have been assessed to determine their conservation status. 30% of amphibians, 23% of mammals and 12% of birds are classified as threatened with extinction, a total of 16000 known species in all. Genetic diversity, which is the basis for adaptation, allowing living organisms to adapt to their natural environment and changes within it, is also believed to be suffering substantial loss, especially in domesticated animals and plants integrated in agricultural systems.

In addition to the general negative trends in many biodiversity indicators, there is increasing concern that *tipping points* may be reached, beyond which ecosystems may be irreversibly degraded. From a human perspective, the potentially catastrophic consequences of the reduction of the capacity of these ecosystems to provide essential services would be most felt by those least able to respond – rural populations typically already in poverty situations (Global Biodiversity Outlook)

2 Policy Responses

Despite increasing effort in conservation, biodiversity continues to decline. New impetus was given to policy measures during the International Year of Biodiversity 2010. Acknowledging the findings of the GBO-3 report, which concludes that "*none of the 21 sub-targets accompanying the overall target of significantly reducing the rate of biodiversity loss by 2010 can be said definitively to have been achieved globally, although some have been partially or locally achieved",* the Convention on Biological Diversity Nagoya Summit adopted a package of measures including the Strategic Plan for Biodiversity 2011-2020 and its associated "Aichi Biodiversity Targets", named after the region in Japan where the summit was held. The United Nations General Assembly has declared 2011-2020 the UN Decade on Biodiversity. These targets are now being incorporated by parties to the CBD in their National Biodiversity Strategies and Action Plans, which are being actively revised with significant support from the CBD secretariat.

Many of the Aichi targets have direct and indirect requirements for reliable and timely information on biodiversity and related themes, whether for providing baseline information on the status, generating indicators for monitoring progress towards targets, regular monitoring of ecosystems and species or alert systems for deviations from expected trends. These are encapsulated in Target 19, which states :

By 2020, 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.

Given the complex nature of the inter-relationships between species, habitats, climate and anthropogenic factors, and the range of scales at which these relationships need to be analysed, there are significant challenges for information discovery, provision, modelling and analysis. Many aspects of these could potentially be addressed by spatial data infrastructure initiatives. The proposed timescales at the policy level, as well as the acceleration of the underlying trends in ecosystem degradation, mean that the response of SDI needs to be rapid.

3 Direct Conservation Measures

Although there is increased recognition that a broad portfolio of conservation measures are necessary in response to the threats to biodiversity (pollution control, managing invasive species, land management, market approaches, community projects), one of the primary direct measures remains the designation of Protected Areas.

Aichi Target 11 states that :

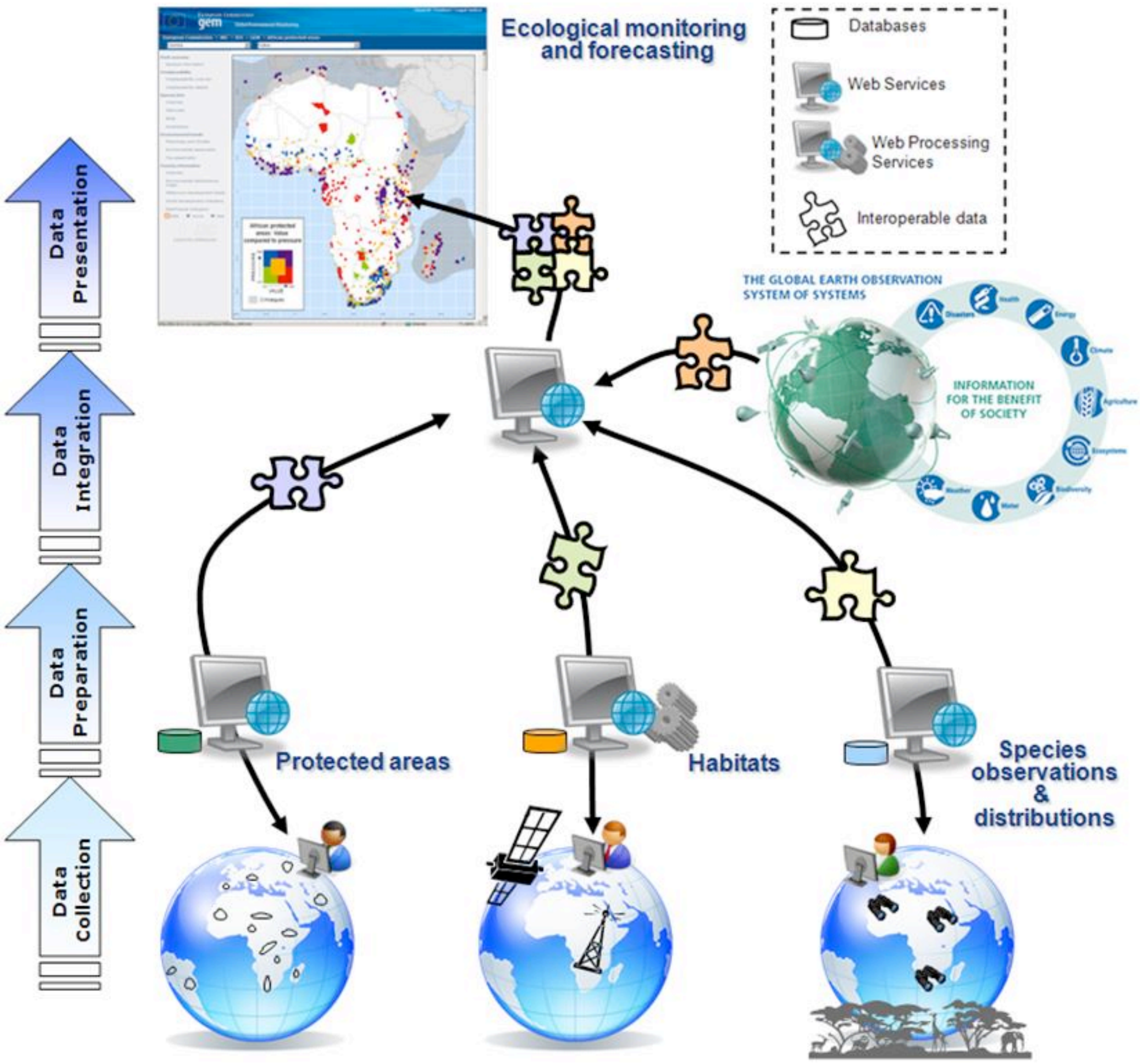
By 2020, at least 17 per cent of terrestrial and inland water, and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes.

Currently, some 13 per cent of terrestrial areas and 5 per cent of coastal areas are protected, while very little of the open oceans are protected. The current target of 10 per cent protection for each ecological region has been achieved in approximately 55 per cent of all terrestrial eco-regions. Therefore reaching this target implies a modest increase in terrestrial protected areas globally, with an increased focus on representivity and management effectiveness. It further implies that major efforts to expand marine protected areas would be required. A focus on representivity is crucial as current protected area networks have gaps, and some fail to offer adequate protection to many species and ecosystems (CBD).

4 Requirements from SDI at the Global Scale

Several global initiatives have attempted to address some of the key shortcomings in information availability for biodiversity, many of which have a strong geospatial component and which therefore fall within the scope of Spatial Data Infrastructure development. The Global Biodiversity Information Facility (GBIF) was established by governments in 2001 to encourage free and open access to biodiversity data, and now provides a series of internet services to access its archive of 319 million indexed records (of which 275 million are geo-referenced), from 8785 datasets from 371 publishers (Feb 2012). UNEP-World Conservation Monitoring Centre, responsible for the maintenance of the World Database on Protected Areas, provides access to information on 160000 sites globally through the website protectedplanet.net. The Census of Marine Life, a 10-year international collaborative effort, with over 30 million species records, and the associated Ocean Biogeographic Information System, implement standards-based methods for geographic data access. The 2009 IUCN Red List of Threatened Species contains assessments for 49,000 species of which spatial data exists for about 25,000 species, including all mammals. The spatial data are available for public download in GIS format. The Joint Research Centre, the in-house science service of the European Commission, is developing the Digital Observatory for Protected Areas (DOPA), a distributed system of information on biodiversity and Protected Areas, joined through interoperable web-services for discovery, data access and for processing (figure 3). DOPA is a contribution to the Group on Earth Observations Biodiversity Observation Network (GEOBON).

Figure 3 - The Digital Observatory for Protected Areas - DOPA



Although from a legal perspective it is only applicable to public authorities in Europe, the INSPIRE Directive is working on data model standardisation for Protected Sites, Species Distribution, Habitats and Biotopes as well as other themes relevant to biodiversity. Contributions to the definition of these data models come from organisations and experts also working globally, and consequently may have a broader geographical impact outside Europe.

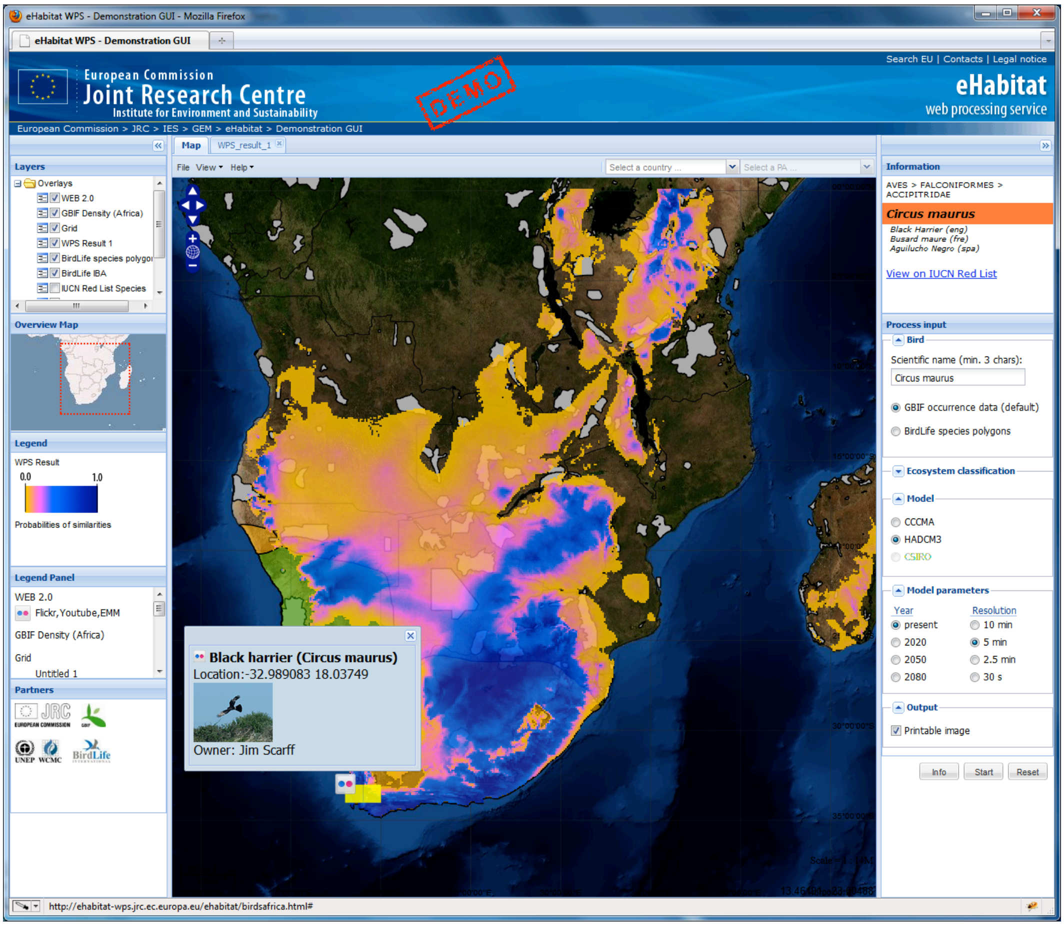
The organisations mentioned above collaborate through various means, including international treaties, inter-governmental organisations, research programmes (of which the European Union 7th Framework Programme – FP7 – has been a major contributor), and professional networks. These activities represent significant progress, yet gaps in information for biodiversity and protected areas management still represent a major problem. Not only is additional information necessary to plan the additional PA's necessary to meet the Aichi targets, but information for sound management and monitoring of the existing network is often lacking, especially socio-economic factors and their relationship with ecological aspects.

5 BIOPAMA – A Project Response in the ACP Region

The African, Caribbean and Pacific Group of States (ACP) is an organisation created by the Georgetown Agreement in 1975. It is composed of 79 African, Caribbean and Pacific states, with all of them, save Cuba, signatories to the Cotonou Agreement, also known as the "ACP-EC Partnership Agreement" which binds them to the European Union. The ACP is the largest recipient of EU development support, with the European Development Fund (EDF) scheduled to provide financing of 22.7bn euro in the period 2008-13. The ACP is home to over 850 million people (2007 estimate) and eleven of the world's twenty-five "biodiversity hotspots".

The Joint Research Centre, the "*in-house science service"* of the European Commission, has long standing expertise in environmental monitoring at the global scale, with specific focus on the humid tropics and the ACP states. In addition to producing global reference datasets (Global Land Cover, Forest Resource Assessment), JRC has developed end-to-end systems such as the eStation which is deployed in 48 countries in sub-saharan Africa as part of the AMESD (African Monitoring of the Environment for Sustainable Development) project. In the biodiversity domain, JRC is concentrating on the development of the Digital Observatory for Protected Areas (DOPA), in partnership with other international organisations, including GBIF, UNEP-WCMC, Birdlife International and RSPB. DOPA builds on previous work to develop an assessment tool of Protected Areas in Africa (Hartley et al, 2007), which used species, habitat, population and climatic data to ranks sites according to the threats they faced and the uniqueness (or "*irreplaceability"*) from a habitat and species perspective. DOPA aims to take advantage of advances in technological infrastructure, particularly in terms of web services and interoperability, to compute similar and additional indicators in real-time, using distributed data sources and models. The eHabitat model (Dubois et al, 2011), one of the first outputs of DOPA, has been implemented using the OGC Web Processing Services (WPS) specification (figure 4). eHabitat is built using Open Source software, using "R" for geostatistical modelling, GDAL for image processing and python (PyWPS) for the web service interface, and consumes OGC Web Coverage Services for input data. This is a major step towards the concept of a "Model Web" for biodiversity (Geller and Turner, 2007), and provides a basis for development of additional indicators. Work is ongoing to develop eSpecies, which will generate via web services a range of species indicators. This is already leading to novel approaches for database management – even a conceptually simple task such as generating a species richness indicator on-the-fly for a given area can involve the overlay of tens of thousands of polygons in a traditional GIS approach.

Figure 4 - The eHabitat Web Processing Service Client



Until now, resources for these developments have mostly been available via research funding, notably FP7 projects including EuroGEOSS and UncertWeb. BIOPAMA (Biodiversity and Protected Areas Management), a 20million euro project, running from 2011-2015, funded by the EDF and jointly managed by JRC and IUCN, requires the setting up of three regional observatories, one for each of the ACP regions, and will greatly improve the capacity of these regions to assess and monitor biodiversity in and around protected areas. BIOPAMA includes a component on Access & Benefit Sharing (ABS), one of the three fundamental objectives of the Convention on Biological Diversity, which promotes "*fair and equitable sharing of the benefits arising out of the utilization of genetic resources, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies, taking into account all rights over those resources and to technologies, and by appropriate funding*". DOPA will provide much of the technical core for the information infrastructure of BIOPAMA, yet clearly there are many external dependencies, some of which are being addressed by initiatives such as GEOBON. These requirements include :

- Easier selection of suitable resources for modelling (input data and services, models) – the "Discovery Augmentation Component" (Nativi et al), developed through the EuroGEOSS and GENESIS FP7 projects, is a promising development in this regard.

- Additional, and more sophisticated, models made accessible on the web, for example using the OGC WPS framework. The number of WPS implementation environments (pyWPS, 52 North, Geoserver WPS, deegree) indicates that this is an active area of development yet, in reality, there are few operational implementations, especially where data volumes are significant. In many ways, the requirements coming from the biodiversity domain are pioneering.

- Workflow engines. If the Model Web vision is realised, then performing a given task may involve interaction with multiple data sources and functions from different providers, and in different ways according to the analysis to be performed. Chaining, or orchestrating, these elements requires a robust and standardised workflow language and associated tools. This is particularly challenging for biodiversity scenarios, which typically involve bringing together information from multiple disciplines.

- Scalability. The biodiversity community deals with complex, global data that represent major challenges for all but the most basic analysis, yet often the organisations required to analyse and manage these data are the ones with least resources for investing in large-scale IT infrastructure. The distributed architectural model, and the recent explosion in opportunities to externalise data hosting through cloud computing, offer potential solutions which have not yet been fully explored.

- Standardisation and comparability. Despite efforts in international and community standardisation, many fundamental datasets and indicators are simply not comparable (different methodologies, different classifications, different input) and therefore of limited benefit for assessing long term trends. In many cases historical data are not archived or properly version-managed.

- Managing uncertainty. If the challenges of quantifying uncertainty in individual datasets were not enough, these are multiplied in distributed architectures allowing their combination in a myriad of ways. This specific problem is being addressed by the FP7 UncertWeb project.

The BIOPAMA project will act as a catalyst in many of these areas, as it is generating requirements that need input from ongoing research programmes and from operational infrastructures and programmes. It will lead to improved data content, increased regional capacity and better analytical tools, but will be heavily influenced by developments in other initiatives, including SDI. During 2012, the architecture of BIOPAMA information systems will be developed, and will rely on continuing improvements in the availability of data and the interoperability of systems as promoted by GSDI and being implemented through programmes such as GEO. Many of the technical challenges for data access and data exchange have been addressed by the SDI community – standards for metadata, catalogues, exchange formats and download web services are well established. Yet uptake is still a problem. Spatial coverage of biodiversity observation is still very incomplete. Availability of time-series data is very limited. Data gaps are most prevalent in the world's least developed regions, which are often the most biodiversity-rich and the most vulnerable (GEOBON, 2011). With 16000 known species classified as threatened with extinction, accelerating negative trends in ecosystem well-being, the threat of exceeding tipping points, international treaty targets in 2020, the urgent need to update National Biodiversity Strategies and Action Plans, there is no time to waste.

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