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Working paper N° A/2012

**Background document:**

**Review of recent publications on indicators of  
Ecosystem Services and Restoration**

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**23 July 2012**

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**Context:**

The Topic Centre has prepared this Working paper in collaboration with the European Environment Agency (EEA) under its 2012 work programmes as a contribution to the EEA's work on the 2020 target.

**Citation:**

Please cite this report as  
Delbaere, B., Torre-Marin, A. and Condé, S., 2012. Background document: Review of recent publications on indicators of Ecosystem Services and Restoration. ETC/BD report to the EEA.

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ETC/BD Working paper N° A/2012  
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# Background document: Review of recent publications on indicators of Ecosystem Services and Restoration

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*This document was prepared by a project team from the European Topic Centre on Biological Diversity – Sophie Condé, MNHN, Amor-Torre Marin and Ben Delbaere, ECNC (May 2012)*

# 1 Introduction

This document presents an overview of current knowledge on indicators on ecosystem services and restoration based on key recent publications. It provides a first rough analysis of indicators in the context of target 2 of the EU 2020 Biodiversity Strategy (EC, 2011): “by 2020, ecosystems and their services are maintained and enhanced by establishing green infrastructure and restoring at least 15 % of degraded ecosystems”. **This overview must be used as a background document in order to help any discussion on selection of indicators on ecosystem services and on restoration.**

This precautionary approach of the use of this document is explained by some of the conclusions of this work:

- Many attempts have been made at global, regional and national levels to identify possible indicators for a range of ecosystem services.
- Identifying indicators connected to ecosystem services very much depends on interpretations and definitions. Ecosystem services can be interpreted in a very broad sense with connections to many sectors and environmental components.
- The indicators presented in tables 3.2 – 3.7 should be reviewed and re-assessed with regard to overlaps between various indicators listed and whether they are indeed ready for immediate use. Moreover, some of the table entries are quite complex and are, in fact, suites of indicators.
- Based on this preliminary list, additional work involving experts needs to be done in order to get a proposal for indicators on ecosystem services and indicators for restoration.

The first part of the report describes the key sources that have been used as a basis for this review. Based on these sources, indicators relevant for the topics of Ecosystem Services and for Restoration were compiled in a separate Excel file as detailed in page 12 in order to prepare a pre-selection presented in the second part of this document. This list of selected of indicators will help for possible further selection and refinement in later steps.

## 2 Sources used for this report

The main documents and reports used as sources of information in the elaboration of this document are summarized below. Full references are provided in the ‘References’ section. Since the EU Biodiversity targets and actions and the Strategic Goals and Aichi Biodiversity targets (CBD, 2010) are mentioned several times in the document, they are listed in Annex I and Annex II respectively.

### 2.1 CBD indicative list of indicators for the Aichi targets

The Ad Hoc Technical Expert Group (AHTEG) on Indicators for the Convention on Biological Diversity (CBD) Strategic Plan for Biodiversity 2011-2020 proposed an indicative list of indicators to assess progress towards the Aichi Targets. In November 2011, CBD SBSTTA15 recommended to CBD COP 11 to adopt a decision recognizing this list as “a starting point to assess progress in the achievement of the Strategic Plan for Biodiversity 2011-2020 at various scales” (CBD, 2011a). Three categories of operational indicators were identified:

- A) Indicators which are ready for use at the global level;
- B) Indicators which could be used at the global level but which require further development to be ready for use;
- C) Additional indicators for consideration for use at the national or other sub-global levels.

The indicators that could be relevant to target 2 of the EU biodiversity strategy to 2020 “by 2020, ecosystems and their services are maintained and enhanced by establishing green infrastructure and

restoring at least 15 % of degraded ecosystems” (EC, 2011) are mainly listed under Aichi targets 14 and 15, which are directly related to restoration.

**Table 2.1: Indicative list of indicators proposed by the AHTEG on indicators for the Strategic Plan for Biodiversity 2011-2020 – Targets 14 and 15. For each indicator the use category (A, B, C – see text) is included. (source: CBD, 2011a)**

Aichi Target	Most relevant operational indicators
<p>Target 14 - By 2020, ecosystems that provide essential services, including services related to water, and contribute to health, livelihoods and well-being, are restored and safeguarded, taking into account the needs of women, indigenous and local communities, and the poor and vulnerable</p>	<p>Trends in distribution, condition and sustainability of ecosystem services for equitable human well-being:</p> <ul style="list-style-type: none"> <li>• Trends in proportion of total freshwater resources used (A) (MDG indicator 7.5)</li> <li>• Trends in proportion of the population using improved water services (A) (MDG indicator 7.8 and 7.9)</li> <li>• Trends in benefits that humans derive from selected ecosystem services (A)</li> <li>• Population trends and extinction risk trends of species that provide ecosystem services (A)</li> <li>• Trends in delivery of multiple ecosystem services (B)</li> <li>• Trends in economic and non-economic values of selected ecosystem services (B)</li> <li>• Trends in health and well-being of communities who depend directly on local ecosystem goods and services (B) (decision VII/30 and VIII/15)</li> <li>• Trends in human and economic losses due to water or natural resource related disasters (B)</li> <li>• Trends in nutritional contribution of biodiversity: Food composition (B) (decision VII/30 and VIII/15)</li> <li>• Trends in incidence of emerging zoonotic diseases (C)</li> <li>• Trends in inclusive wealth</li> <li>• Trends in nutritional contribution of biodiversity: Food consumption (C) (decision VII/30 and VIII/15)</li> <li>• Trends in prevalence of underweight children under-five years of age (C) (MDG indicator 1.8)</li> <li>• Trends in natural resource conflicts (C)</li> <li>• Trends in condition of selected ecosystem services (C)</li> <li>• Trends in biocapacity (C)</li> </ul> <p>Trends in coverage, condition, representativeness and effectiveness of protected areas and other area-based approaches:</p> <ul style="list-style-type: none"> <li>• Trends in area of degraded ecosystems restored or being restored (B)</li> </ul>
<p>Target 15 - By 2020, ecosystem resilience and the contribution of biodiversity to carbon stocks has been enhanced, through conservation and restoration, including restoration of at least 15 per cent of degraded ecosystems, thereby contributing to climate change mitigation and adaptation and to combating desertification</p>	<p>Trends in distribution, condition and sustainability of ecosystem services for equitable human well-being:</p> <ul style="list-style-type: none"> <li>• Status and trends in extent and condition of habitats that provide carbon storage (A)</li> </ul> <p>Trends in coverage, condition, representativeness and effectiveness of protected areas and other area-based approaches:</p> <ul style="list-style-type: none"> <li>• Population trends of forest-dependent species in forests under restoration (C)</li> </ul>

## 2.2 GEO BON report on adequacy of biodiversity information systems

The Group on Earth Observation Biodiversity Observation Network (GEO BON), the International Union for Conservation of Nature (IUCN) and the United Nations Environment Programme World Conservation Monitoring Centre (UNEP-WCMC) prepared a report on “Adequacy of Biodiversity information Systems to support the CBD 2020 Targets” in support of the meeting of the AHTEG on Indicators for the Strategic Plan for Biodiversity 2011-2020 (GEO BON, 2011).

The report states that Target 14 does not yet have a globally adequate observation system, but work is rapidly developing towards one for key services. For target 15 some observation systems are technically feasible and some global-scale databases exist that could serve as pilots. The report also contains a section on ‘gaps and data limitations’, ‘adequacy of assessment’ and ‘estimated costs’ to reach adequacy under each target (GEO BON, 2011).

According to the report, prioritizing ecosystem services to be monitored is a difficult choice since different services contribute to human well-being in a variety of different ways and are valued differently by the different actors. A critical task is also to understand the complex trade-offs among and between services. Sources of information to monitor the list of services will include that derived from remote sensing, national and subnational statistics, local quantification of services in a network of sites, as well as models developed at multiple spatial scales (GEO BON, 2011).

Regarding restoration, the report states that there are no known currently active processes or databases documenting ecosystem restoration activities worldwide. It may be possible to establish a mechanism for compiling such a dataset in relation to reporting requirements under ARD (Afforestation, Reforestation, Deforestation under the Kyoto Protocol), REDD+ (Reducing Emissions from Deforestation and Forest degradation in Developing Countries including the role of conservation, sustainable management of forests and enhancement of forest carbon stocks) activities in the framework of the United Nations Framework Convention on Climate Change (UNFCCC), CDM (The Clean Development Mechanism of the UNFCCC), the private sector Voluntary Carbon Standard (VCS) process and project databases under the United Nations Convention to Combat Desertification (UNCCD) and the Global Environment Facility (GEF) (GEO BON, 2011).

The GEOBON report has presented existing observation datasets which can be the basis for monitoring progress towards biodiversity targets. Variables and/or indicators can be derived from these datasets. All are listed below:

**Table 2.2: Initial list of variable/datasets/indicators for monitoring progress towards Targets 14 and 15 (extracted from GEO BON, 2011)**

Observation dataset	Start Year	Frequency of update	Geographical Coverage	Spatial Resolution	Source and Organizational Holder/s
<b>Target 14</b>					
Total crop production <sup>1</sup>	1980	Annual	Global	National	The FAO Statistical Database (FAOStat)
Total wood production <sup>2</sup>	1980	Annual	Global	National	Forest Resource Assessment/FAOStat
Livestock production <sup>3</sup>	1961	Annual	Global	National	FAOStat
Fisheries production <sup>4</sup>	1950	Annual	Global	National	FAOStat/FishStat
Biofuel production <sup>5</sup>	1961	Annual	Global	National	FAOStat
Water supply for domestic use	1958	Annual	Global	National	FAO's global information system on water and agriculture (AQUASTAT); WorldBank

<sup>1</sup> Includes total crop production for forage

<sup>2</sup> Includes fuel wood production

<sup>3</sup> Live animals + livestock processed

<sup>4</sup> Freshwater fisheries + marine fisheries + aquaculture

<sup>5</sup> Production of oil seed crops

Observation dataset	Start Year	Frequency of update	Geographical Coverage	Spatial Resolution	Source and Organizational Holder/s
Water supply for irrigation	1958	Annual	Global	National	AQUASTAT, WorldBank
Nutrient retention for clean drinking water		Seasonal/ Annual	Global	National	Integrated Valuation of Ecosystem Services and Trade-offs (InVEST) and The Lund-Potsdam-Jena Dynamic Global Vegetation Model (LPJ model)
Erosion control <sup>6</sup> (for reservoir maintenance)		Seasonal/ Annual	Global	National	InVEST and LPJ
Climate regulation <sup>7</sup>	1981	hourly/daily/ monthly	Global	National	World Data Centre for Greenhouse Gases (WDCGG)
Nature-based tourism <sup>8</sup>	1990s	Annual	Global	National	IUCN/WCPA task force
Population trends for services-delivering species groups (e.g. pollinators, scavengers, seed dispersers) <sup>9</sup>	1970-1980s	1-5 years	Regional to global	National to continental	FAO; African Pollinator Initiative (API); LPI database (WWF/ZSL); WBI database (BirdLife International/EBCC/N ABCI-US Committee)
Extinction risk trends for service-delivering species groups (e.g. pollinators, scavengers, seed dispersers)	1980 (amphibians); 1988 (birds); 1996 (mammals)	4-10 years	Global	Meaningful disaggregation by taxonomic group, region or biome possible	IUCN Red List and RLI dataset (IUCN, BirdLife International, etc)
<b>Target 15</b>					
<b>Greenhouse gas fluxes</b>					
Atmospheric concentration of GHGs, plus N <sub>2</sub> O and isotopes	1970, on-going	Monthly	Global	Continental, improving	Global Atmospheric Watch
Anthropogenic emissions of GHGs	1990, on-going	Annual	Global	National	ORNL Distributed Active Archive Center (DAAC)
Fluxes from specific ecosystems	About 2000, on-going	Hourly, annualised	Global but patchy	Points of ~1km radius	FLUXNET (about 500 flux towers in a range of ecosystems)
Emissions/uptake of CO <sub>2</sub> , CH <sub>4</sub> and N <sub>2</sub> O by ecosystems	Under development	Annual	Global modelled product	~50 km	GEO BON Ecosystem Services working group
<b>Monitoring desertification and dryland restoration and climate change</b>					

<sup>6</sup> Measure currently being developed by InVEST and LPJ, needs expansion/adaptation

<sup>7</sup> Includes NO<sub>2</sub> and Methane via carbon-equivalents

<sup>8</sup> Under development, needs to be developed from scratch

<sup>9</sup> Measures need to be developed

Observation dataset	Start Year	Frequency of update	Geographical Coverage	Spatial Resolution	Source and Organizational Holder/s
FAPAR or related vegetation greenness proxies	1996	10-daily	Global	300m	ESA, NASA and several other space agencies
Albedo	2000	10-daily	Global	500m	NASA (MODIS or Multi-angle Imaging Spectroradiometer (MISR)); ESA (Medium Resolution Imaging Spectrometer (MERIS))
Climate driver variables - rain, temperature, humidity, wind, biomass, soil carbon, fire extent	Some exists since 1850 but more are in preparation	Various, depending on variable, but mostly at least annual	Global	Variable, but typically gridded to about 50km	Global Climate Observing System (GCOS) Essential Climate Variables
<b>Carbon stocks</b>					
Forest extent and biomass by type. Supplementary information on age and species composition	Databases for some types and regions exist since 1970	5-yearly	Global forested areas	~30m	Does not yet comprehensively exist, but under development among by GEO Forest Carbon Tracker, UNDP and others. FAO Forest Resources Assessment (FRA) is also a source and potential host for a consolidated set
Wetland extent and carbon density by type	Databases for some types exist since ~1970	5-yearly	Global	~30m	Does not yet exist. Ramsar mapping activity will help produce it. Wetlands International may be a logical host for a consolidated set
pCO <sub>2</sub> of the ocean and related indicators such as calcium carbonate compensation depth	~1950	Continuous recording from cruises	Global but uneven	~100km	NOAA (Takahashi dataset)
<b>Restoration of degraded ecosystems</b>					
Database of Restoration actions: net GHG forcing outcomes and biodiversity impacts	Does not yet exist	Database would be continuously updated as projects report	Global, but only covering areas within REDD+ or restoration projects	Project scale	Does not yet exist, but could be based on registers of Carbon offset and REDD+ programmes, e.g. Indonesia's Forest Resource Information System (FRIS), Afforestation, Reforestation, Deforestation (ARD), Clean Development Mechanism (CDM) & Voluntary Carbon Standards (VCS)



Observation dataset	Start Year	Frequency of update	Geographical Coverage	Spatial Resolution	Source and Organizational Holder/s
<b>Vulnerability to climate change</b>					
Indicator of vulnerability based on organism traits	Under development	Single time, updated decadal	Global	Broad ecosystem type	IUCN, in collaboration with others
<b>Resilience</b>					
Connectivity within site habitat fragmentation and between site connectivity	Various (UMD GLC from 1998; GLCC from 2000; GlobCover from 2005)	Various	Global (subglobal datasets also available)	Down to high resolution satellite images (c. 20m). Scaling up to 1km but varies (GlobCover is 300m)	Site managers; Global land cover datasets

### 2.3 Report on developing ecosystem service indicators

The UNEP-WCMC report on “Developing ecosystem service indicators: Experiences and lessons learned from sub-global assessments and other initiatives” takes stock of the key lessons that have been learned in developing and using ecosystem service indicators in a range of assessment contexts. The analysis covers 11 Sub-global assessments and includes 137 indicators that were classified according to the Millennium Ecosystem Assessment (MA)/The Economics of Ecosystems and Biodiversity (TEEB) framework of 22 service types under four key service themes (UNEP-WCMC, 2011).

**Table 2.3: Classification of ecosystem services (Source: UNEP-WCMC, 2011)**

Service category	Service types
Provisioning	<ol style="list-style-type: none"> <li>1. Food</li> <li>2. Water</li> <li>3. Raw materials</li> <li>4. Genetic resources</li> <li>5. Medicinal resources</li> <li>6. Ornamental resources</li> </ol>
Regulating	<ol style="list-style-type: none"> <li>7. Air quality regulation</li> <li>8. Climate regulation (including carbon sequestration)</li> <li>9. Moderation of extreme events</li> <li>10. Regulation of water flows</li> <li>11. Waste treatment</li> <li>12. Erosion prevention</li> <li>13. Maintenance of soil fertility</li> <li>14. Pollination</li> <li>15. Biological control</li> </ol>
Habitat/Supporting	<ol style="list-style-type: none"> <li>16. Lifecycle maintenance (e.g. migratory species, nursery habitat)</li> <li>17. Maintenance of genetic diversity</li> </ol>
Cultural [provide opportunities for:]	<ol style="list-style-type: none"> <li>18. Aesthetic enjoyment</li> <li>19. Recreation and tourism</li> <li>20. Inspiration for culture, art and design</li> <li>21. Spiritual experience</li> <li>22. Cognitive development</li> </ol>

The report contains a table of indicators for the Aichi Targets, which includes the following information:

- Strategic Goal
- Target

- Indicator
- Ecosystem service group
- Implementation: 2011/2020
- Cost effectiveness: National scale/Global scale
- Notes

However, the report states that the table is presented largely unedited as a resource for use in further discussion, so it should not be considered an exhaustive list or comparable between targets. The report also contains fact sheets for selected ecosystem service indicators used in sub-global assessments which provide more detailed information about these indicators.

The most common and well developed indicators are for provisioning services, for which the most data exist; some regulating service indicators are well developed; for cultural services information on tourism and recreation is most frequently collected. Key messages for indicator and assessment practitioners highlighted in the report are (UNEP-WCMC, 2011):

- Ensure objectives are clear
- Adopt a small set of specific, policy relevant indicators
- Go beyond provisioning services
- Utilize existing data and proxies (but recognize limits)
- Think about sustainability – include indicators for both ecosystems and benefits
- Include biodiversity
- Be sensitive to scale
- Assess trends and consider synergies and trade-offs
- Engage stakeholders early
- Focus on communication

## 2.4 Report on green infrastructure implementation and efficiency

Ecosystem services indicators for measuring green infrastructure effectiveness are listed in the report ‘Green infrastructure implementation and efficiency’ (Mazza et al., 2011). The report does not provide additional information such as data availability for the individual indicators; however, in some cases there is an analysis of the suitability of specific indicators to measure different ecosystem services provision. The indicators are listed following the ecosystem services classification.

The report indicates that indicators on functional diversity may have some potential for measuring the delivery of some regulating services. Quantitative indicators that measure the status and trends in habitat area and species population often show clear links to some provisioning services; they can also be applied to the measurement of cultural services linked to ecosystem and species of social or cultural value; they are also potentially useful indicators of regulating services that rely on biomass or a particular habitat, such as carbon sequestration, pollination, erosion control and water flow regulation. Biodiversity indicators that have been developed at global and EU levels have as main purpose to monitor biodiversity status and trends and ecosystem condition or pressures rather than ecosystem services provision. The ones that can be applied to the measurement of ecosystem services mainly reflect the stock of services rather than the flow of benefits. Indicators developed for the measurement of specific ecosystem processes in most cases do not clearly show the link of such processes with the benefits they underpin; in addition, it is difficult to scale up the results to national or regional level (Mazza et al., 2011).

Available indicators for provisioning services in many cases are derived from other sectors (e.g. forestry, agriculture, fisheries) and provide a more complete picture of the services than most regulating and cultural services (Layke, 2009 in Mazza et al., 2011). Since indicators of food and timber provision in general include direct measures of crop, livestock, fish and timber production they should be complemented with others that assess the sustainability aspect (Mazza et al., 2011).

Partly due to the complexity of quantifying processes, indicators of regulating services are generally less developed and some of the existing ones have been produced in the context of other policy areas

such as climate change or pollution control (Mazza et al., 2011). An additional challenge in the identification of indicators of regulating services is that in certain cases the indicator would be a measure of avoided change, which entails measuring a negative occurrence that has not happened due to the contribution of a regulating service (Layke 2009 in Mazza et al., 2011).

The number of people visiting a site to enjoy its amenity values or to make use of its recreation and tourism opportunities is a commonly used indicator for cultural services. Regarding supporting services, most indicators of nutrient cycling relate to soil processes and the functional or taxonomic groups of organisms underpinning them. At the landscape level, various characteristics of the ecosystems which are known to play a role in nutrient cycling have been suggested as proxy indicators for service provision. In relation to maintenance of genetic diversity, the degree of landscape connectivity can be used as a proxy since landscape patterns influence the process of gene flow (Mazza et al., 2011).

## **2.5 Possible indicators for water and water-related ecosystem services**

Possible indicators for water and water-related ecosystem services for the Strategic Plan for Biodiversity 2011-2020 and the Aichi Biodiversity Targets were also compiled in an information document for the fifteenth meeting of the Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) (CBD, 2011b). The indicators are grouped in three primary indicator areas:

1. Clean water
2. Water availability/water security
3. Sediment transfer

The preliminary short list of key indicators was identified based on criteria including indicator availability and/or ease of development. For each indicator the following information is provided:

- Relevant targets: Main target; additional targets
- Justification
- Relevant biodiversity storyline
- A description of metrics and data availability
- Constraints

Most of the indicators are already in use by other processes in particular the Millennium Development Goal (MDG) indicators and by the Commission on Sustainable Development and most are in use at national level. Some of the indicators are direct measures of ecosystem services (benefits), some are drivers of service degradation, whilst some are both. The document also contains some of the indicators in use or being considered for the UNCCD highlighting indicators with particular relevance to the indicator framework for the Aichi biodiversity Targets (CBD, 2011b).

## **2.6 Swiss Inventory of Final Ecosystem Goods and Services**

The Federal Office for the Environment (FOEN) of Switzerland has drawn up a list of relevant ecosystem goods and services that forms the starting point for the “Inventory of Final Ecosystem Goods and Services”. A methodology was developed for reviewing and further developing the inventory (validation) and also for creating indicators (operationalization). The result is an inventory of 23 ecosystem services relevant to Switzerland as well as proposals for indicators for the individual services and the data base for those indicators. The indicators are a selection chosen according to the criterion ‘direct connection to welfare’ (Staub et al., 2011).

## **2.7 Additional references**

The following references were also used as sources of information and relevant indicators have been included in the complete table:

- SEBI indicators (EEA, 2012)
- ETC/BD report on analysis of national indicator products (ETC/BD, 2011)

- Towards European Ecosystem Assessments: A Knowledge Base for European Ecosystem Assessments. Conceptual Framework (Andersson and Powell, 2011a)
- Towards European Ecosystem Assessments: Pilot Population and Analytical Review of Ecosystem Assessments Knowledge Base (Andersson and Powell, 2011b)
- UK National Ecosystem Assessment Technical Report and mainly Chapter 13: Supporting Services, Chapter 14: Regulating Services, Chapter 15: Supporting Services and Chapter 16: Cultural Services (UK NEA, 2011).
- Portugal Millennium Ecosystem Assessment: State of the Assessment Report (Pereira et al., 2004).

### 3 Classification and first selection of indicators

Around 340 indicators listed in the sources that are described in the previous section have been compiled in a complete separate Excel table (Appendix 1) and organized according to their relevance to the Aichi biodiversity targets. The detailed information provided in the different sources for the individual indicators has been included as columns in the table. Their headings are described below. Since the various sources in general provide different detail of information for the individual indicators, the table presents many blank entries. No additional research has been done to complete all the entries for the individual indicators.

The columns/entries used in the general table are the following:

- Indicator: it might be some of these entries are observation datasets meaning calculation is needed to get an indicator in the sense it will provide a signal of change.
- Global/EU/Local: indicators that are relevant at the European/EU level have been classified under 'EU'. Indicators that are mainly relevant at the global or local level have been classified under 'Global' and 'Local' respectively. However, most part of the indicators classified under 'EU' could be also relevant at the global and local levels.
- Selection (1/2/blank): indicators classified under '1' are indicators that would be ready to use, (at least at Global level) according to the sources. This include: indicators that are already in use by other processes; data are available to produce the indicator; the indicator is classified under 'Implementation 2011' in UNEP-WCMC, 2011. Indicators classified under '2' are indicators that could be used for some countries or areas; for which measures/methodologies should be further developed; or that could be derived from other data. The rest of indicators are not ready to use and the field in this column is blank.
- Comments: additional information and clarifications.
- Ecosystem services/restoration: indicates if the indicator is relevant to ecosystem services or to restoration.
- Ecosystem service group (Cultural/Multiple /Provisioning/Regulating/ Supporting): indicates for which ecosystem service group the indicator could be relevant. Indicators that could be relevant to several services are classified under 'Multiple'.
- Aichi target: indicates to which Aichi target the indicator could be relevant. In some cases more than one target is listed.
- Implementation 2011: indicates if the indicator could be implemented by 2011 for indicators listed in the UNEP-WCMC report (UNEP-WCMC, 2011).
- Implementation 2020: indicates if the indicator could be implemented by 2020 for indicators listed in the UNEP-WCMC report (UNEP-WCMC, 2011).
- Cost effectiveness national scale.
- Cost effectiveness global scale.
- Start year: year when data started to be collected.
- Frequency of update.
- Geographical coverage.
- Spatial resolution.
- Source and organization holder.
- Reference: source where the indicator is listed.
- Link: link to the source where the indicator is listed.

A first selection of indicators was done for indicators which were indicated as ready to use by the authors of the report (classified under '1' in the 'Selection' column). The selection includes 96 indicators that are presented below in five different tables (table 3.2 – 3.6) according to their relevance to the different ecosystem service groups:

Table 3.2: First selection of indicators – Cultural

Table 3.3: First selection of indicators - Provisioning

Table 3.4: First selection of indicators - Regulating

Table 3.5: First selection of indicators - Supporting

Table 3.6: First selection of indicators - Multiple

Indicators that could be relevant to restoration are listed again in table 3.7. The balance is as follows:

**Table 3.1: First selection of indicators – balance according to ecosystem service groups**

Some indicators can be classified in several groups.

<b>Ecosystem service group</b>	<b>Number of indicators</b>
Cultural	5
Provisioning	26
Regulating	19
Supporting	7
Multiple	39
<b>Total</b>	<b>96</b>

**Table 3.2: First selection of indicators – Cultural**

N	Indicator / observation dataset	Comments	Aichi Target	Source / organizational holder	Reference
1	Number of members of environmental NGOs		1, 19		UNEP-WCMC, 2011
2	Number of staff working at NGOs	Could be divided into paid staff and volunteers	1, 19		UNEP-WCMC, 2011
3	Number of staff working for environment agencies	May be difficult to decide who to include here	1, 19		UNEP-WCMC, 2011
4	Number of people taking part in recreation activities	This would need to be broken down and potentially reported for different activities	1		UNEP-WCMC, 2011
5	Citizen science (number of biological records/year)	Possibly use the data available through GBIF	19		UNEP-WCMC, 2011

**Table 3.3: First selection of indicators - Provisioning**

N	Indicator/ observation dataset	Comments	Aichi Target	Source / organizational holder	Reference
1	Absolute amount and proportional share of renewable energy sources in final electricity consumption	There are data in EUROSTAT	4		Staub et al., 2011
2	Harvested fish combined with safe ecological limits		6		UNEP-WCMC, 2011
3	Fisheries: European commercial fish stocks	SEBI 21	6	GFCM and ICES	EEA, 2012
4	Red List Index - threatened species		6		UNEP-WCMC, 2011
5	Fish and wildlife production	Trends in production	6, 8, 9, 14		UNEP-WCMC, 2011
6	Fisheries production		6	FAOStat/FishStat	GEO BON, 2011
7	Total crop production		7	The FAO Statistical Database (FAOStat)	GEO BON, 2011
8	Crop water productivity	In use	7	FAO and IWMI	CBD, 2011b
9	Livestock production		7	FAOStat	GEO BON, 2011

<b>N</b>	<b>Indicator/ observation dataset</b>	<b>Comments</b>	<b>Aichi Target</b>	<b>Source / organizational holder</b>	<b>Reference</b>
10	Forest certification - extent of FSC schemes	Already developed as part of the 2010 Biodiversity Indicators set	7		UNEP-WCMC, 2011
11	Total wood production		7	Forest Resource Assessment/FAOStat	GEO BON, 2011
12	Forest: growing stock, increment and fellings	SEBI 17 (also in Mazza et al., 2011)	7	MCPFE, EFI	EEA, 2012
13	Biofuel production		7	FAOStat	GEO BON, 2011
14	Sustainable practices of fish/shellfish/etc production		7		UNEP-WCMC, 2011
15	Proportion of population using an improved sanitation facility (MDG indicator 7.9)	In use	8	WHO and UNESCO	CBD, 2011b
16	Fish and wildlife production from protected areas	Trends in production	11		UNEP-WCMC, 2011
17	Biodiversity for food and medicine	RLI cuts for key species	14		UNEP-WCMC, 2011
18	Capacity of soils to sustain agropastoral use	UNCCD indicator	14	GLADIS "Soil Health Status"	CBD, 2011b
19	Trends in proportion of total freshwater resources used (A) (MDG indicator 7.5)	MDG indicator 7.5	4, 14	MDGs	CBD, 2011a
20	Water scarcity (or proportion of total water resources used)	In use	14	FAO AQUASTAT	CBD, 2011b
21	Trends in proportion of the population using improved water services (A) (MDG indicator 7.8 and 7.9)	MDG indicator 7.8 and 7.9	14	MDGs	CBD, 2011a
22	Proportion of population using an improved drinking water source (MDG indicator 7.8)	In use	14	WHO and UNESCO	CBD, 2011b
23	Water use intensity by economic activity	In use	4, 14	Commission on Sustainable Development	CBD, 2011b



N	Indicator/ observation dataset	Comments	Aichi Target	Source / organizational holder	Reference
24	Water supply for domestic use		14	FAO's global information system on water and agriculture (AQUASTAT); WorldBank	GEO BON, 2011
25	Water supply for irrigation		14	AQUASTAT, WorldBank	GEO BON, 2011
26	Actual hydropower installed capacity/potential capacity	In use	14	World Bank	CBD, 2011b

**Table 3.4: First selection of indicators - Regulating**

N	Indicator/ observation dataset	Comments	Aichi Target	Source / organizational holder	References
1	Area water-logged by irrigation	In use	7	FAO AQUASTAT	CBD, 2011b
2	Area salinized by irrigation	In use	7	FAO AQUASTAT	CBD, 2011b
3	Water quality	In use	8, 14	World Water Assessment Programme	CBD, 2011b
4	Trends in water quality per use category	Possible for most countries	8, 14		UNEP-WCMC, 2011
5	Dead zones	Linked to sustainable management and the ability for ecosystem service delivery	8		UNEP-WCMC, 2011
6	Wastewater treatment	In use	8	Commission on Sustainable Development	CBD, 2011b
7	Status of pollinating species	Red List Index for pollinating birds and mammals and by 2020 potentially possible a sampled insect pollinators index and a Living Planet Index for pollinating vertebrates	12, 14	BirdLife International	UNEP-WCMC, 2011
8	Landscape configuration and suitability for pollinators	Draw on the work undertaken by the Natural Capital Project	12, 14		UNEP-WCMC, 2011
9	Status of pest controlling species	A Red List Index for pest controlling vertebrates could be developed now	12, 14		UNEP-WCMC, 2011

N	Indicator/ observation dataset	Comments	Aichi Target	Source / organizational holder	References
10	Avoided costs of not using pesticides		12		UNEP-WCMC, 2011
11	Disease outbreaks linked to loss of ecosystem function	Possible for a selection of water borne diseases	14		UNEP-WCMC, 2011
12	Nutrient retention for clean drinking water		14	Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) and The Lund-Potsdam-Jena Dynamic Global Vegetation Model (LPJ model)	GEO BON, 2011
13	Land affected by desertification	In use	14, 15	Commission on Sustainable Development	CBD, 2011b
14	Human and economic losses due to natural disasters	In use	14	Commission on Sustainable Development	CBD, 2011b
15	Percentage of population living in natural hazard prone areas	In use	14	Commission on Sustainable Development	CBD, 2011b
16	Number of flood events	Indication of the failure of the ecosystem service	14, 15		UNEP-WCMC, 2011
17	Anthropogenic emissions of GHGs		15	ORNL Distributed Active Archive Center (DAAC)	GEO BON, 2011
18	Value of carbon (\$/Tonnes C)	In forest and ideally all natural habitats	15		UNEP-WCMC, 2011
19	Ocean CO2 flux		15		UNEP-WCMC, 2011

**Table 3.5 : First selection of indicators - Supporting**

N	Indicator/ observation dataset	Comments	Aichi Target	Source / organizational holder	References
1	Conservation status of habitats and species	SEBI 3 and SEBI 5	5, 12	DG ENV and ETC/BD	Mazza et al., 2011
2	Net Primary Production (NPP)	This indicator would be implemented as a model using remote sensing data	14		UNEP-WCMC, 2011
3	Food web integrity/efficiency	e.g. Marine Trophic Index	14		UNEP-WCMC, 2011

<b>N</b>	<b>Indicator/ observation dataset</b>	<b>Comments</b>	<b>Aichi Target</b>	<b>Source / organizational holder</b>	<b>References</b>
4	Climate moisture index (CMI) (Aridity index)	In use	14	FAO AQUASTAT and WMO	CBD, 2011b
5	Soil fertility/organic matter	Existing maps are static and trends in application of fertilisers may be more useful if it is linked to soil fertility	8, 14, 15		UNEP-WCMC, 2011
6	Connectivity: within site, habitat fragmentation and between site, connectivity		11, 14	Site managers; Global land cover datasets	GEO BON, 2011
7	Soil Carbon	Possible in some regions like Europe but to make this cost-effective, means you would lose the detail and preciseness. The indicator would need to be linked to other indicators to understand the changes in the carbon stocks	15		UNEP-WCMC, 2011

**Table 3.6: First selection of indicators - Multiple**

<b>N</b>	<b>Indicator / observation dataset</b>	<b>Comments</b>	<b>Aichi Target</b>	<b>Source / organizational holder</b>	<b>Reference</b>
1	Waste generation	There are data in EUROSTAT	4		ETC/BD, 2011
2	Change in land use	UNCCD indicator	5		CBD, 2011b
3	Land use for agriculture in hectares		5		Staub et al., 2011
4	Land use for forestry in hectares		5		Staub et al., 2011
5	Ecosystem coverage	SEBI 4; Data from CLC	5	EEA, LEAC, CLC	EEA, 2012
6	Area of Marine Protected Areas in place to protect fish stocks		6		UNEP-WCMC, 2011
7	Area of agro-ecosystems under sustainable management		7		UNEP-WCMC, 2011
8	Agriculture: nitrogen balance	SEBI 19	7	OECD	EEA, 2012

N	Indicator / observation dataset	Comments	Aichi Target	Source / organizational holder	Reference
9	Agriculture: area under management practices potentially supporting biodiversity	SEBI 20	7	JRC and EEA, Eurostat	EEA, 2012
10	Forest age structure		7	MCPFE	ETC/BD, 2011
11	Forest: deadwood	SEBI 18	7	MCPFE, EFI	EEA, 2012
12	Aquaculture: effluent water quality from finfish farms	SEBI 22	7	FAO Fishstat plus	EEA, 2012
13	Nutrients in transitional, coastal and marine waters	SEBI 15	8	EEA Waterbase	EEA, 2012
14	Freshwater quality	SEBI 16	8	EEA Waterbase verion 6 and 7	EEA, 2012
15	National distribution of areas that has particular importance for ecosystem services. What about 'well connected' and protected? State indicator on protected areas and their cohesion?	This indicator would use an overlay of maps of protected areas and components of ecosystem services	11, 14 ?		UNEP-WCMC, 2011
16	Trends in mangroves and other coastal vegetation areas under protection	A number of coastal/marine habitats form part of the 2010 Biodiversity Indicators set	11		UNEP-WCMC, 2011
17	Forest ecosystems effectively protected		11		UNEP-WCMC, 2011
18	Ecosystem services provided by PAs	Possible for some services and baselines for some countries. Datasets could include WDPA, carbon, water, tourism, spiritual sites, NTFPs	11, 14		UNEP-WCMC, 2011
19	Management effectiveness of PAs, including habitat fragmentation/degradation		11		UNEP-WCMC, 2011
20	Extinction risk trends for service-delivering species groups (e.g. pollinators, scavengers, seed dispersers)		14	IUCN Red List and RLI dataset (IUCN, BirdLife International, etc)	GEO BON, 2011
21	Status of domesticated animals: number of native breeds		13		UNEP-WCMC, 2011
22	Population affected by water-related diseases	In use	14	FAO AQUASTAT	CBD, 2011b

<b>N</b>	<b>Indicator / observation dataset</b>	<b>Comments</b>	<b>Aichi Target</b>	<b>Source / organizational holder</b>	<b>Reference</b>
23	Water security	Includes measures for quality, quantity and use and water borne disease trends	14		UNEP-WCMC, 2011
24	Carbon stock	Possible in some regions like Europe	14		UNEP-WCMC, 2011
25	Carbon stocks above and below ground	UNCCD indicator	14		CBD, 2011b
26	Global terrestrial carbon stocks		14	FAO/IIASA/ISRIC/ISS-CAS/JRC (2009); Ruesch and Gibbs (2008); Scharlemann et al. (in prep.)	UNEP-WCMC, 2011
27	Trends in area and fragmentation of ecosystems	This indicator could focus on wetlands, forest, mangroves, areas important for ecosystem services as defined by the country	14		UNEP-WCMC, 2011
28	Fragmentation of natural and semi-natural areas	SEBI 13	14	JRC, EFDAC	EEA, 2012
29	Impact of river fragmentation	Siltation, water quantity and quality change, IAS, etc owing to dam construction, commercial water extraction and use	14		UNEP-WCMC, 2011
30	Habitat connectivity	This is already a biodiversity indicator developed as part of the 2010 set with the focus on forest fragmentation. Though its relevance to ES (e.g. pollination, water and tourism) needs to be explored further	14		UNEP-WCMC, 2011
31	Sites of particular importance for biodiversity and carbon storage/sequestration protected/restored		15		UNEP-WCMC, 2011
32	Degree of land degradation	UNCCD indicator	14		CBD, 2011b
33	Extent of forest restored		14		UNEP-WCMC, 2011
34	Area of forests protected plus the percentage of 2010 degraded ecosystems restored		15		UNEP-WCMC, 2011
35	Status and trends in extent and condition of habitats that provide carbon storage (A)		15		CBD, 2011a

N	Indicator / observation dataset	Comments	Aichi Target	Source / organizational holder	Reference
36	pCO <sub>2</sub> of the ocean and related indicators such as calcium carbonate compensation depth		15	NOAA (Takahashi dataset)	GEO BON, 2011
37	Proportion of countries with appropriate national legislation		16		UNEP-WCMC, 2011
38	Red List Index of medicinal plants		16		UNEP-WCMC, 2011
39	Progress in implementation of Integrated Water Resources Management (IWRM)	In use	19		CBD, 2011b

**Table 3.7: First selection of indicators – Restoration**

N	Indicator/ observation dataset	Comments	Aichi Target	Source / organizational holder	Reference
1	Connectivity: within site, habitat fragmentation and between site, connectivity		11, 14	Site managers; Global land cover datasets	GEO BON, 2011
2	Sites of particular importance for biodiversity and carbon storage/sequestration protected/restored		15		UNEP-WCMC, 2011
3	Degree of land degradation	UNCCD indicator	14		CBD, 2011b
4	Extent of forest restored		14		UNEP-WCMC, 2011
5	Area of forests protected plus the percentage of 2010 degraded ecosystems restored		15		UNEP-WCMC, 2011
6	Status and trends in extent and condition of habitats that provide carbon storage (A)		15		CBD, 2011a

## 4 Preliminary conclusions

On the basis of the **current broad-brush review**, the following preliminary conclusions can be drawn:

1. Many attempts have been made at global, regional and national levels to identify possible indicators for a range of ecosystem services.
2. The ongoing initiatives appear to be undertaken without many attempts at streamlining.
3. Only few indicators in the sources that have been reviewed address restoration of ecosystems (or restoration of ecosystem services).
4. Although variables/datasets/indicators related to Aichi targets 14 and 15 are most directly connected to ecosystem services and restoration, variables/datasets and indicators listed under other targets could also relate to ecosystem services and restoration (and vice versa).
5. Identifying indicators connected to ecosystem services very much depends on interpretations and definitions. Ecosystem services can be interpreted in a very broad sense with connections to many sectors and environmental components.
6. The indicators presented in tables 3.2 – 3.7 should be reviewed and re-assessed with regard to overlaps between various indicators listed and whether they are indeed ready for immediate use. Moreover, some of the table entries are quite complex and are, in fact, suites of indicators.
7. Based on this preliminary list, additional work involving experts needs to be done in order to get a proposal for indicators on ecosystem services and indicators for restoration.

# Annex 1: EU Biodiversity targets and actions

Target/Action	
<b>Target 1</b>	<b>Fully implement the Birds and Habitats Directives</b>
Action 1	Complete the establishment of the Natura 2000 network and ensure good management
Action 2	Ensure adequate financing of Natura 2000 sites
Action 3	Increase stakeholder awareness and involvement and improve enforcement
Action 4	Improve and streamline monitoring and reporting
<b>Target 2</b>	<b>Maintain and restore ecosystems and their services</b>
Action 5	Improve knowledge of ecosystems and their services in the EU
Action 6	Set priorities to restore and promote the use of green infrastructure
Action 7	Ensure no net loss of biodiversity and ecosystem services
<b>Target 3</b>	<b>Increase the contribution of agriculture and forestry to maintaining and enhancing biodiversity</b>
Action 8	Enhance direct payments for environmental public goods in the EU Common Agricultural Policy
Action 9	Better target Rural Development to biodiversity conservation
Action 10	Conserve Europe's agricultural genetic diversity
Action 11	Encourage forest holders to protect and enhance forest biodiversity
Action 12	Integrate biodiversity measures in forest management plans
<b>Target 4</b>	<b>Ensure the sustainable use of fisheries resources</b>
Action 13	Improve the management of fished stocks
Action 14	Eliminate adverse impacts on fish stocks, species, habitats and ecosystems
<b>Target 5</b>	<b>Combat Invasive Alien Species</b>
Action 15	Strengthen the EU Plant and Animal Health Regimes
Action 16	Establish a dedicated instrument on Invasive Alien Species
<b>Target 6</b>	<b>Help avert global biodiversity loss</b>
Action 17	Reduce indirect drivers of biodiversity loss
Action 18	Mobilise additional resources for global biodiversity conservation
Action 19	'Biodiversity proof' EU development cooperation
Action 20	Regulate access to genetic resources and the fair and equitable sharing of benefits arising from their use



## Annex 2: Strategic Goals and Aichi Biodiversity targets

Goal/target	
<b>Strategic Goal A</b>	<b>Address the underlying causes of biodiversity loss by mainstreaming biodiversity across government and society</b>
Target 1	By 2020, at the latest, people are aware of the values of biodiversity and the steps they can take to conserve and use it sustainably.
Target 2	By 2020, at the latest, 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.
Target 3	By 2020, at the latest, incentives, including subsidies, harmful to biodiversity are eliminated, phased out or reformed in order to minimize or avoid negative impacts, and positive incentives for the conservation and sustainable use of biodiversity are developed and applied, consistent and in harmony with the Convention and other relevant international obligations, taking into account national socio-economic conditions.
Target 4	By 2020, at the latest, Governments, business and stakeholders at all levels have taken steps to achieve or have implemented plans for sustainable production and consumption and have kept the impacts of use of natural resources well within safe ecological limits.
<b>Strategic Goal B</b>	<b>Reduce the direct pressures on biodiversity and promote sustainable use</b>
Target 5	By 2020, the rate of loss of all natural habitats, including forests, is at least halved and where feasible brought close to zero, and degradation and fragmentation is significantly reduced.
Target 6	By 2020 all fish and invertebrate stocks and aquatic plants are managed and harvested sustainably, legally and applying ecosystem based approaches, so that overfishing is avoided, recovery plans and measures are in place for all depleted species, fisheries have no significant adverse impacts on threatened species and vulnerable ecosystems and the impacts of fisheries on stocks, species and ecosystems are within safe ecological limits.
Target 7	By 2020 areas under agriculture, aquaculture and forestry are managed sustainably, ensuring conservation of biodiversity.
Target 8	By 2020, pollution, including from excess nutrients, has been brought to levels that are not detrimental to ecosystem function and biodiversity.
Target 9	By 2020, invasive alien species and pathways are identified and prioritized, priority species are controlled or eradicated, and measures are in place to manage pathways to prevent their introduction and establishment.
Target 10	By 2015, the multiple anthropogenic pressures on coral reefs, and other vulnerable ecosystems impacted by climate change or ocean acidification are minimized, so as to maintain their integrity and functioning.
<b>Strategic Goal C</b>	<b>To improve the status of biodiversity by safeguarding ecosystems, species and genetic diversity</b>
Target 11	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

Goal/target	
	and well connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscape and seascapes.
Target 12	By 2020 the extinction of known threatened species has been prevented and their conservation status, particularly of those most in decline, has been improved and sustained.
Target 13	By 2020, the genetic diversity of cultivated plants and farmed and domesticated animals and of wild relatives, including other socio-economically as well as culturally valuable species, is maintained, and strategies have been developed and implemented for minimizing genetic erosion and safeguarding their genetic diversity.
<b>Strategic Goal D</b>	<b>Enhance the benefits to all from biodiversity and ecosystem services</b>
Target 14	By 2020, ecosystems that provide essential services, including services related to water, and contribute to health, livelihoods and well-being, are restored and safeguarded, taking into account the needs of women, indigenous and local communities, and the poor and vulnerable.
Target 15	By 2020, ecosystem resilience and the contribution of biodiversity to carbon stocks has been enhanced, through conservation and restoration, including restoration of at least 15 per cent of degraded ecosystems, thereby contributing to climate change mitigation and adaptation and to combating desertification.
Target 16	By 2015, the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization is in force and operational, consistent with national legislation.
<b>Strategic Goal E</b>	<b>Enhance implementation through participatory planning, knowledge management and capacity building</b>
Target 17	By 2015 each Party has developed, adopted as a policy instrument, and has commenced implementing an effective, participatory and updated national biodiversity strategy and action plan.
Target 18	By 2020, the traditional knowledge, innovations and practices of indigenous and local communities relevant for the conservation and sustainable use of biodiversity, and their customary use of biological resources, are respected, subject to national legislation and relevant international obligations, and fully integrated and reflected in the implementation of the Convention with the full and effective participation of indigenous and local communities, at all relevant levels.
Target 19	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.
Target 20	By 2020, at the latest, the mobilization of financial resources for effectively implementing the Strategic Plan 2011-2020 from all sources and in accordance with the consolidated and agreed process in the Strategy for Resource Mobilization should increase substantially from the current levels. This target will be subject to changes contingent to resources needs assessments to be developed and reported by Parties.

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