European Commission

Mapping and Assessment of Ecosystems and their Services

An analytical framework for ecosystem assessments under Action 5 of the EU Biodiversity Strategy to 2020.

Discussion paper – Final, April 2013

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Summary

Action 5 of the EU Biodiversity Strategy to 2020 calls Member States to map and assess the state of ecosystems and their services in their national territory with the assistance of the European Commission. The objective of this discussion paper is to support the development of a coherent analytical framework to be applied by the EU and its Member States in order to ensure consistent approaches are used.

In line with the Millennium Ecosystem assessment, the objective of the EU assessment is to provide a critical evaluation of the best available information for guiding decisions on complex public issues. It is therefore framed by a broad set of key policy questions. It is structured around a conceptual framework that links human societies and their well-being with the environment. More specifically, the paper proposes a typology of ecosystems to be assessed and mapped and the use of the Common International Classification of Ecosystem Services (CICES) developed for environmental accounting purposes.

CONTENTS

EXECUTIVE SUMMARY

Context.

Action 5 of the EU Biodiversity Strategy to 2020 calls Member States to map and assess the state of ecosystems and their services in their national territory with the assistance of the European Commission. The results of this mapping and assessment should support the maintenance and restoration of ecosystems and their services. A Working Group on Mapping and Assessment on Ecosystems and their Services (MAES) was set up under the Common Implementation Framework (CIF), the governance structure to underpin the effective delivery of the EU Biodiversity Strategy to 2020. The objective of the MAES Working Group is to support the implementation of Action 5 by the EU and its Member States. The first action of the Working Group was to support the development of a coherent analytical framework to be applied by the EU and its Member States in order to ensure consistent approaches are used.

Objectives of the discussion paper.

This discussion paper is a resource document that compiles background information and provides the basis for a common conceptual framework and a toolkit to ensure coherent mapping and assessment across Europe and across scales. This should be considered as a support tool for MS when mapping and assessing their national territory, to identify their national priorities and to make use of the proposed common typology of ecosystems and ecosystem services that allows for consistent aggregation across scales and comparison of results.

Content of the discussion paper.

Section 1 provides information on the policy context within which the MAES initiative is taking place, i.e. the EU 2020 Biodiversity Strategy, targets and actions as well as on the governance of the MAES working group. This section is also providing information on related developments in the international context (e.g. Intergovernmental Platform on Biodiversity and Ecosystem Services - IPBES).

Section 2 identifies the broad set of key policy questions that frames the EU assessment that aims to provide a critical evaluation of the best available information for guiding decisions on complex public issues.

Section 3 proposes a conceptual framework for ecosystem assessments under action 5: The conceptual framework links socio-economic systems with ecosystems via the flow of ecosystem services and through the drivers of change that affect ecosystems either as consequence of using the services or as indirect impacts due to human activities in general.

Section 4 proposes a coherent typology to be used for the different types of broad ecosystems to be considered in the assessment to ensure consistency across Member States. There is a need to agree on which ecosystems and services will be considered in priority by EU and its Member States.

Section 5 addresses the linkages between existing typologies for ecosystem services. The general framework developed by the Common International Classification of Ecosystem Services (CICES) is proposed for the integration of economic values of ecosystem services into accounting and reporting systems at EU and national level. The framework also provides cross-reference with ecosystem services categories used in assessments (e.g. Millennium Ecosystem Assessment - MA, The Economics of Ecosystems and Biodiversity – TEEB). This very general framework provides a flexible and hierarchical classification system that can be adapted to specific situation and needs of Member States.

Section 6 summarizes the tasks to be completed and potential sources of information, methods and tools to be used:

I. Biophysical baseline mapping and assessment of the status of major ecosystems;
II. Biophysical baseline mapping and assessment of defined ecosystem services;
III. Alignment of ecosystem service assessments with scenarios of future changes (future outlooks), developed together with policy makers and stakeholders to ensure their salience and legitimacy and consequently the use of the results in decision making;
IV. Valuation of ecosystem services for baseline and contrasting scenarios and integration into environmental and economic accounting.

Section 7 identifies next steps.

Mapping and Assessment of Ecosystems and their Services

AN ANALYTICAL FRAMEWORK FOR ECOSYSTEM ASSESSMENTS UNDER ACTION 5 OF THE EU BIODIVERSITY STRATEGY TO 2020. DISCUSSION PAPER – FINAL

1 INTRODUCTION

The headline target overarching the EU Biodiversity Strategy to 2020 (1) and adopted by EU Heads of States and Governments in March 2010 is the following:

> "Halting the loss of biodiversity and the degradation of ecosystem services in the EU by 2020, and restoring them in so far as feasible, while stepping up the EU contribution to averting global biodiversity loss"

The EU 2020 Biodiversity Strategy, which includes six targets and 20 associated actions responds to both EU and global mandate, setting the EU on the right track to meet its own biodiversity objectives and its global commitments under the Convention on Biological Diversity (CBD).
With regard to what happens inside the EU, a necessary condition for implementing the Biodiversity Strategy (based on the principle that you can't manage what you can't or don't measure (2)) is comprehensive and robust information concerning the status of biodiversity, ecosystems and ecosystem services across the EU and the capacity to monitor changes. If we do not know what the status is now and what it will be in 2020 it will be impossible to assess whether or not we have achieved our target(s). Similarly, in 2010, it was not possible to quantify by how much the target of halting biodiversity loss in the EU by that date had been missed.

The information and knowledge base upon which the Biodiversity Strategy is developed will integrate and streamline the latest outcomes from the reporting under the Birds and Habitats Directives, the Water Framework Directive, the Marine Strategy Framework Directive, and other relevant data flows reported under environmental legislation, including spatial data such as the Natura 2000 network, river basins, marine regions, etc. Reliable data on the status of species and habitats such as EU Red-Lists or independent scientific reports on the status of different taxonomic groups such as birds and butterflies will also be taken into account. Through the mapping and assessment of ecosystems and their services (Action 5 of the Biodiversity Strategy) the role of the implementation by Member States of EU environmental legislation and policy in the delivery of ecosystem services should be evaluated (e.g. contribution of Natura 2000 network to the delivery of services, integration of ecosystem services in future design of river basin management plans under the Water Framework Directive and in the marine strategies under the Marine Strategy Framework Directive).

Action 5 of the Biodiversity Strategy requires ***Member States, with the assistance of the Commission, to map and assess the state of ecosystems and their services in their national territory by 2014, assess***

the economic value of such services, and promote the integration of these values into accounting and reporting systems at EU and national level by 2020"

In December 2011, the European Council acknowledged that the maintenance and restoration of ecosystems and their services should be supported by the results of mapping and assessment of the state of ecosystems and their services and in view of the short timeframe for initiating this work, urged the Commission and Member States to determine the modalities for and scope of these tasks building upon the work carried out by the Member States[1].

The objective of the Working Group on Mapping and Assessment on Ecosystems and their Services (MAES) set up under the Common Implementation Framework (CIF) is to support the implementation of Action 5 by the EU and its Member States.

1.1 Action 5 in relation to the Targets and Actions of the Biodiversity Strategy

Although Action 5 is formally associated with Target 2 of the Biodiversity Strategy it is clear that its scope goes much further than this and that it underpins the achievement of many of the targets and the other actions in the strategy[2]. Figure 1 illustrates how actions under Target 2 link to each other.

1.1.1 Target 1 and associated Actions 1 and 4.

The concept of ecosystem services has great potential in adding value to current conservation approaches, in particular the maintenance and restoration of ecosystems enhancing their conservation status which is the primary objective of the nature directives. Recent work at European scale (3) shows that habitats in a favourable conservation status provided more biodiversity and had a higher potential to supply, in particular, regulating and cultural ecosystem services than habitats in an unfavourable conservation status. Action 5 is therefore of importance in identifying regions in which measures are likely to result in cost-effective progress towards both new biodiversity conservation and ecosystem services targets adopted by the Biodiversity Strategy.

Improvement of the conservation status of species and habitats covered by the Birds and Habitats Directives will make a significant contribution towards the achievement of the headline target – to maintain, restore and avoid degradation of biodiversity and ecosystem services - and these improvements will need to be accounted for in the monitoring and assessment under Action 5. In addition, improvements to the monitoring and reporting regimes under the two directives should also be seen as a contribution to the work under Action 5.

1.1.2 Target 2 and associated Actions 6 and 7.

Target 2 aims for the restoration of 15% of degraded ecosystems and the deployment of Green Infrastructure. Action 6a provides for the development of a strategic framework for setting priorities for restoration at the national and sub-national levels. Action 6b foresees the development of a Green Infrastructure Strategy. Action 7a is designed to reduce the impact of EU funded projects on biodiversity and Action 7b foresees the European

1 http://consilium.europa.eu/media/1379139/st18862.en11.pdf

2 For more information, see http://biodiversity.europa.eu/ecosystem-assessments/

Commission making a proposal on no net loss of biodiversity and ecosystem services. Sound information on the state of ecosystems and ecosystem services now and on a projected "business as usual" scenario until 2020, will provide the necessary reference points in relation to the achievement of Target 2 and implementing all its associated actions/sub-actions.

Action 5 and the work undertaken by MAES should have strong linkages to the work being undertaken on mapping and assessment in relation to the EU's agenda on territorial cohesion (spatial planning and territorial development). Many of the maps, tools, and indicators being developed in this context such as the Urban Atlas[3], Quickscan[4], and Landscape Ecological Potential (4), respectively, have direct relevance for Action 5.

DG REGIO is contributing to MAES by supporting work on ecosystems and their services at regional (NUTS2) level using the JRC's Land Use Modelling Platform (5). The objective of this work is twofold: to assess the endowment of EU NUTS 2 regions in ecosystems providing some of the benefits which are the most relevant for cohesion policy; to estimate the use/exploitation and vulnerabilities of the actual goods and services in a wider frame of regional development.

1.1.3 Target 3 and associated Actions

Target 3 is concerned with increasing the contribution of agriculture and forestry to maintaining and enhancing biodiversity. Action 5 will clearly involve the mapping and assessment of biodiversity and ecosystems on agricultural and forest land and it is very important that the mapping and spatial information systems which are used to inform the implementation of the Biodiversity Strategy are coordinated and compatible with the maps and spatial information systems such as CAPRI[5] which are used to inform the implementation of the Common Agricultural Policy (CAP).

The results of MAES should help designing rural development programmes that best locate and optimise benefits for farmers, foresters and biodiversity under the CAP so as to ensure the conservation of biodiversity and to bring about a measurable improvement in the species and habitats that depend on or are affected by agriculture and forestry and in the provision of ecosystem services.

1.1.4 Target 4

Target 4 is concerned with ensuring the sustainable use of fisheries resources and the improvement of the status of the marine environment. Action 5 will address this target specifically in close co-ordination and coherence with the implementation of the Marine Strategy Framework Directive and the Common Fisheries Policy.

A dedicated workshop on mapping and assessment of marine ecosystems and their services is planned for June 2013. The workshop will investigate how the application of the ecosystem approach, through the implementation of the Marine Strategy Framework Directive, could support the implementation of the EU integrated maritime

[3] http://www.eea.europa.eu/data-and-maps/data/urban-atlas

[4] Quickscan: A pragmatic approach for bridging gaps in the science-policy interface; Manuel Winograd (European Environment Agency), Marta Perez-Soba (ALTERRA), Peter Verweij (ALTERRA), Rob Knappen (ALTERRA), LIAISE OPEN DAY, Bilbao, Spain, 14 March, 2012.

[5] Common Agricultural Policy Regionalised Impact Modelling System; http://www.capri-model.org/

policy and also how the work could contribute to the regular UN process for global reporting and assessment of the state of the marine environment, including socio-economic aspects.

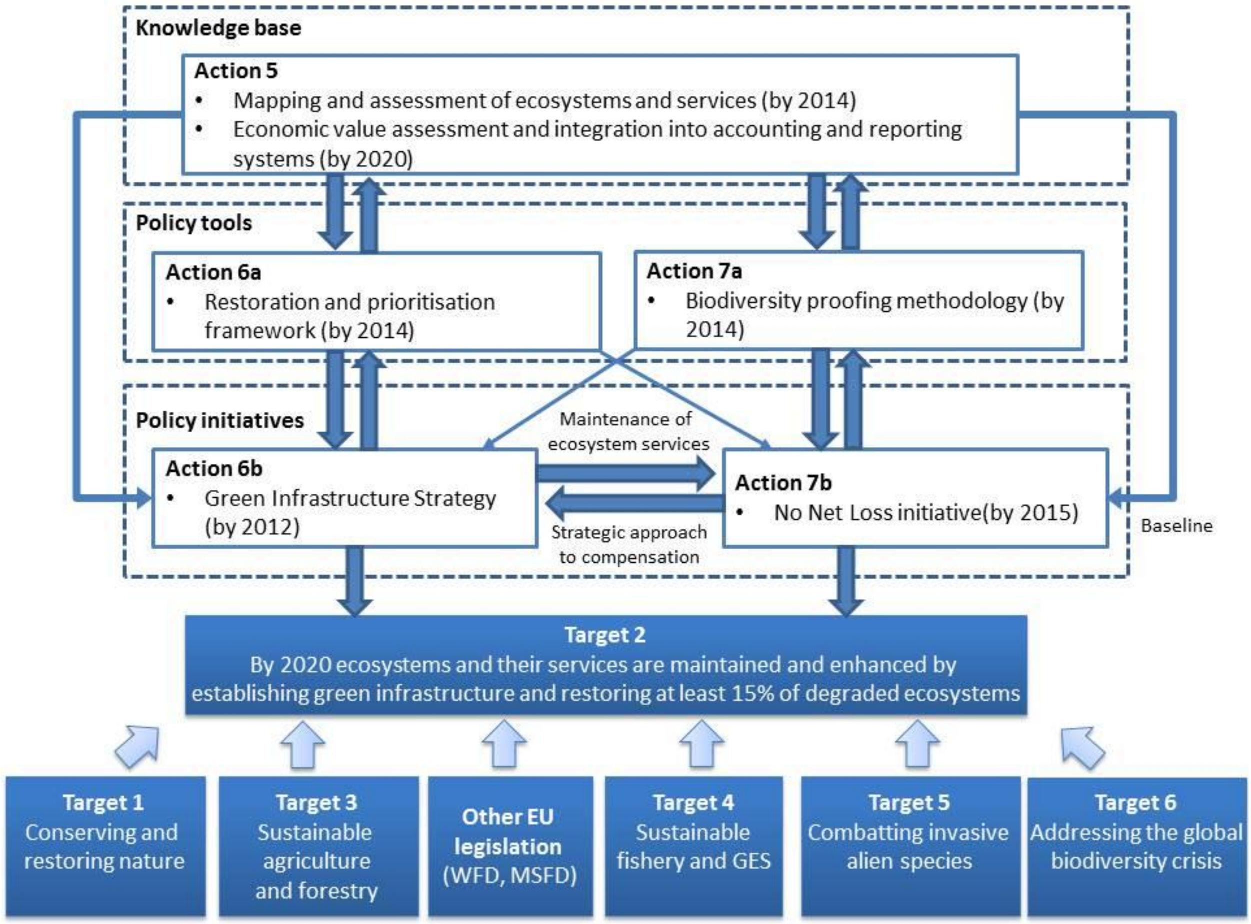

Figure 1. Importance of Action 5 in relation to other supporting Actions under Target 2 and to other Targets of the EU Biodiversity Strategy.

1.1.5 Target 5

Target 5 on combatting Invasive Alien Species, along with its associated supporting actions, is not at this stage strongly linked to the work on mapping and assessment. However, in the future, data concerning the presence and location of Invasive Alien Species, which are major threats to biodiversity could be integrated progressively into the system[6].

[6] DG Environment is supporting the development by the Joint Research Centre of the European Alien Species Information Network http://easin.jrc.ec.europa.eu/ and by the European Environment Agency of an application on Eye-on-Earth that allows citizens to record their observations through mobile phones. http://eea.maps.arcgis.com/home/

1.1.6 Target 6

Target 6 is concerned with the contribution of the EU to halting global biodiversity loss[7]. This includes the contribution of the EU and its Member States to the implementation of the Global Strategic Plan for Biodiversity 2011-2020 of the Convention on Biodiversity (CBD) and the commitment to reach its Aichi Targets. MAES work will contribute to the EU response to Aichi targets 2, 14 and 15, through restoring 15% of degraded ecosystems by 2020, thereby contributing to climate change mitigation and adaptation, and through integrating biodiversity values in accounting systems.

Progress on implementing the Actions under Target 2 will be monitored and the results will feed into the preparation of both the EU mid-term report in 2015 and the EU's fifth National Report as required under the CBD in 2014.

Box 1. Three targets of the global Strategic plan for Biodiversity, 2011-2020 in relation to Action 5

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 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.

1.2 Broader international linkages

1.2.1 IPBES and future IPBES regional assessments

At a future date sub-global assessments of ecosystems and ecosystem services will be undertaken as a contribution to the IPBES process. The conceptual framework for IPBES assessments is currently being discussed within the scientific community. The work of MAES being done under Action 5 is an important stepping stone to the future assessment work to be done by the EU in connection with IPBES[8]. Synergies should be enhanced and it is expected that MAES would benefit from and contribute to the IPBES developments, including from strengthened science-policy interface building strongly on existing institutions.

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[7] The Digital Observatory for Protected Areas (DOPA) is a component of the GEO-BON observation network by the Joint Research Centre in collaboration with other international organizations including the Global Biodiversity Information Facility (GBIF), the UNEP-World Conservation Monitoring Centre (WCMC), Birdlife International and the Royal Society for the Protection of Birds (RSPB). DOPA is conceived as a set of distributed databases combined with open, interoperable web services to provide a large variety of end-users including park managers, decision-makers and researchers with means to assess, monitor and forecast the state and pressure of protected areas at the global scale. http://dopa.jrc.ec.europa.eu/

[8] http://ipbes.unepwcmc-004.vm.brightbox.net/assessments/75

1.2.2 Natural Capital Accounts

The UN Statistics Division (UNSD) is developing experimental standards for ecosystem capital accounting in the context of the revision of its SEEA (System of Environmental-Economic Accounting) handbook[9]. This work will be finalised in 2013. Methodological developments are heavily supported by the European Environment Agency (EEA), and Eurostat who is representing the European Commission in the EEA Drafting Group. The RIO +20 meeting saw the launch of a natural capital declaration with the objective of getting such accounts integrated into annual business reports. The World Bank also launched the 50:50 initiative to gather political support for national natural capital accounting, and is piloting methodological developments in developing countries through the Wealth Accounting and Valuation of Ecosystem Services (WAVES) Partnership, which is supported amongst other donors by the UK, France, Germany and the EU.

National natural capital accounts will clearly be based on coarse aggregated indicators. However, for these statistics to be meaningful they should reflect the state of ecosystems in the territory concerned. This being the case, there is clearly a strong link between Action 5, the work of MAES, the work on natural capital accounts and the green economy.

1.3 Challenges

1.3.1 Operationalising ecosystem services

In the short-term, the essential challenge of Action 5 is to make the best use of and to operationalise the information and scientific knowledge currently available on ecosystems and their services in Europe to guide policy decisions. Importantly, the knowledge base must be accessible to Member States for mapping and assessment in their territory. The work to be undertaken under Action 5 will strongly build on the outcomes of the Millennium Ecosystem Assessment (MA) work and The Economics of Ecosystems and Biodiversity (TEEB) studies (6, 7). It will also capitalise on the experience and newly developed knowledge from on-going assessments, in particular the national TEEB studies and sub global MA assessments currently undertaken by several Member States. The ecosystem assessment under Action 5 will benefit from the outcomes of the reporting obligations of the Member States under EU environmental legislation on the status of biotic components of ecosystems (i.e. ecological status of water bodies, conservation status of protected species and habitat types and environmental status of the marine environment) and abiotic environmental conditions such as air quality including greenhouse gas emissions, surface water, groundwater and marine water quantity and physico-chemical quality. The analytical framework should therefore be sufficiently flexible to accommodate the results from on-going European, national and sub-national assessments while enabling the inclusion of future assessments and further more detailed information as it becomes available.

1.3.2 The link between ecosystems, ecosystems services and biodiversity

This Action needs to integrate growing scientific evidence (8-15) on biodiversity as a key component for resilient ecosystems. As a general principle, ecosystem services need to be mapped in their integrity based on the potential of ecosystems to deliver multiple services, and analysing their interdependency and potential trade-offs.

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9 http://unstats.un.org/unsd/envaccounting/seea.asp

This means, for example, for agriculturally used areas to consider species and habitat conservation status, erosion regulation, pollination, pest and disease control services, water purification/regulation services, recreation and cultural diversity and lifecycle maintenance of cropland ecosystems instead of focusing on mapping exclusively the maximum potential of food production (16). Similarly, ecosystem services might depend on interactions of multiple ecosystem types or on different temporal stages, and cannot always be expressed in linear relationships. The assessment of the multiple ecosystem services in combination with the analysis of synergies and trade-offs between these services is the basis for valuing the multi-functionality of ecosystems for human well-being. This implies however, that different layers of information have to be included: actual use and service delivery as well as potential or future use and information on how increasing one service will impact on other services provided by the same area or an area nearby. The challenge thus consists in designing a methodology with which to begin the work that is flexible enough to be expanded and refined at later dates.

1.4 The Scope of Action 5 and MAES

The mapping and assessment of ecosystems and ecosystem services is one of the keystones of the EU Biodiversity Strategy. The initial methodological work on biophysical mapping and assessment is expected to be delivered by 2014. The work carried out by the EU and its Member States will also contribute to the assessment of the economic value of ecosystem services, and promote the integration of these values into accounting and reporting systems at EU and national level by 2020.

The results from this work will be used to inform policy decisions and policy implementation in many areas, such as nature and biodiversity, territorial cohesion, agriculture, forestry and fisheries. Outputs can also inform policy development and implementation in other domains, such as transport and energy.

The potential outreach of the Action 5 work has implications for its governance, the methodology as well as the level of resources necessary to support the MAES process.

1.5 Governance

1.5.1 General

The MAES working group has been set up within the Common Implementation Framework of the Biodiversity 2020 Strategy. Its membership as well as the membership of its associated steering group is limited in number and the nature of the discussions in the group is predominantly technical. The Co-ordination Group for Biodiversity and Nature (CGBN) is the forum in which the wider policy issues related to the work of MAES are discussed. In addition, thematic workshops (e.g. marine) will be organised in 2013 to allow for more in-depth discussion with different sectors and stakeholders.

1.5.2 The need to involve the scientific community

The mapping and assessment of biodiversity and ecosystems is a resource intensive activity. To guarantee the quality and acceptability of the output of Action 5, independent scientists will need to be involved in the process. Rather than working with individual scientists at the EU level this could be done by working with scientific societies and networks, for instance the Ecosystem Services Partnership[10]. With the support of the Directorate General for Research and Innovation (DG RTD) mechanisms for engaging with the scientific community are being explored. For instance, earlier versions of this paper have been discussed at meetings of the Biodiversity Knowledge Network[11] and at the 3rd European Congress of Conservation Biology[12] and their recommendations have been implemented in this version. Also ALTER-Net[13] will dedicate a special session to MAES at a conference on the science underpinning the EU 2020 Biodiversity Strategy and the European Platform for Biodiversity Research Strategy (EPBRS) [14] will address how science can help attaining targets of the EU 2020 Biodiversity Strategy at a Conference organised by the Irish Presidency in May 2013.

The involvement of DG RTD could also serve to inform the implementation of the Horizon 2020 agenda in relation to the knowledge base required for biodiversity policy. Member states will have a key role in mobilizing and involving scientific expertise in the MAES work at the national level. As several examples, including the UK-NEA (17) have shown there is an enormous potential for collaboration in this field.

1.5.3 The role of Member States and stakeholders

The spatial resolution at which ecosystems and services are mapped and assessed will vary depending on data availability and the purpose for which the mapping/assessment is carried out. Different policy sectors (environment, agriculture, regional development, etc.) have different information needs and the level of detail required for local level decisions will not be the same as the indicators used for informing EU policy development. We need to be realistic about the degree of convergence that is achievable but we should ensure an optimum level of consistency and avoid wasting money and resources. The European Commission and associated Agencies have valuable experience and expertise but there is also a wealth of information and experience available in the Member States and among stakeholders that should be shared.

Box 2. Why mapping ecosystems and their services?

Maps are useful for spatially explicit prioritisation and problem identification, especially in relation to synergies and trade-offs among different ecosystem services, and between ecosystem services and biodiversity. Further, maps can be used as a communication tool to initiate discussions with stakeholders, visualizing the locations where valuable ecosystem services are produced or used and explaining the relevance of ecosystem services to the public in their territory. Maps can - and to some extent already do - contribute to the planning and management of biodiversity protection areas and implicitly of their ecosystem services at sub-national level. However, the mentioned purposes will not be attempted through the sole mapping exercise, but rather through the combination of digital mapping with the assessment of the supply of ecosystem services related to their demand (including the spatial interactions between them).

At the European level, mapping can assist decision makers in identifying priority areas, and relevant policy measures, including the improvement of the targeting of measures and in demonstrating/evaluating their benefits in relation to costs (e.g. impact assessment) via spatially explicit reporting obligations from the Member States.

[10] http://www.es-partnership.org/esp

[11] http://www.biodiversityknowledge.eu/

[12] http://www.eccb2012.org/

[13] http://www.alter-net.info/

[14] http://www.epbrs.org/

2 POLICY QUESTIONS

Ultimately, the assessment of ecosystems and their services in Europe needs to address a broad range of policy questions, such as those presented in Table 1. In addition, Member States and sectorial policies will have much more specific questions as well. This list of questions will therefore be revisited and evolve over time and priorities may shift also depending on the approaches chosen and the questions prioritized by the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES).

Table 1. Broad policy questions to be addressed

Q1	What are the current state and trends of the EU's ecosystems and the services they provide to society? What are emerging trends and projected future state of the EU's ecosystems and the services they provide to society? How is this currently affecting human well-being and what are the projected, future effects to society?
Q2	What are the key drivers causing changes in the EU's ecosystems and their services?
Q3	How does the EU depend on ecosystem services that are provided outside the EU?
Q4	How can we secure and improve the continued and sustainable delivery of ecosystem services?
Q5	How do ecosystem services affect human well-being, who and where are the beneficiaries, and how does this affect how they are valued and managed?
Q6	What is the current public understanding of ecosystem services and the benefits they provide (some key questions could usefully be included in the 2013 Eurobarometer on Biodiversity)?
Q7	How should we incorporate the economic and non-economic values of ecosystem services into decision making and what are the benefits of doing so (question to be addressed 2020)? And what kind of information (e.g. what kind of values) is relevant to influence decision-making?
Q8	How might ecosystems and their services change in the EU under plausible future scenarios - What would be needed in terms of review/revision of financing instruments?
Q9	What are the economic, social (e.g. employment) and environmental implications of different plausible futures? What policies are needed to achieve desirable future states?
Q10	How have we advanced our understanding of the links between ecosystems, ecosystem functions and ecosystem services? More broadly, what is the influence of ecosystem services on long-term human well-being and what are the knowledge constraints on more informed decision making (question to be addressed to the European Commission (DG RTD and Joint Research Centre) and research community in the context of EU mechanism, KNEU[15], and SPIRAL[16]).

[15] http://www.biodiversityknowledge.eu/
[16] http://www.spiral-project.eu/

In the short-term, the implementation of Action 5 will need to respond to specific policy needs (Table 2) that was presented to stakeholders for an in-depth discussion at the MAES workshop of 20-21 November 2012.

Table 2. Examples of specific questions to be addressed under Action 5 of the EU 2020 Biodiversity Strategy

Q11	How can MAES assist MS in assessing and reviewing the priorities to be set for ecosystem restoration within a strategic framework at sub-national, national and EU level? How can MAES help to assess and review the design of prioritisation criteria for restoration and at which scale to get significant benefits in a cost-effective way (e.g. relevance for biodiversity; extent of degradation of ecosystems and the provision of key ecosystem services)?
Q12	How can MAES help to provide guidance and tools to support strategic deployment of green infrastructure in the EU in urban and rural areas to improve ecosystem resilience and habitat connectivity and to enhance the delivery of ecosystem services at Member State and sub-national level? How to foster synergies between existing and planned initiatives at local, regional or national levels in Member States, as well as how to promote further investments, thereby providing added value to Member States action?

3 A CONCEPTUAL FRAMEWORK FOR ECOSYSTEM ASSESSMENT

Following two commenting rounds by various experts and considering the outcomes of the discussion at the 2nd and 3rd MAES working group meetings in June and September 2012, this paper constitutes an amended proposal for a conceptual framework.

This paper provides the entry points for different stakeholder groups and different assessments of ecosystems. When discussing the first version of the conceptual frame (cf. MAES analytical framework discussion paper of 4 June 2012), the need to better include various institutions, stakeholders and users group in the framework, was strongly encouraged; whereas the importance of ecosystem functions as pre-condition for the delivery of ecosystem services was not explicitly emphasized, nor were the drivers of change which affect ecosystems. Finally, it was felt that biodiversity would require a stand-alone dimension in the conceptual frame and both the DPSIR and the cascade frameworks, if included, would require important simplification. A follow up discussion at the 3rd MAES meeting revealed that biodiversity was still insufficiently depicted. In addition, there was a request to specify the different components of human well-being.

The present proposal is based on the ecosystem services cascade model (18), the TEEB framework (19), and the UK National Ecosystem Assessment (17). It also contains elements of the DPSIR framework[17] and is adapted to better fit the needs of ecosystem assessments under Action 5. In the following we first outline the overall framework and then present its elements and their relationships in more detail.

3.1 Overall conceptual framework

In its simplest version the conceptual framework links socio-economic systems with ecosystems via the flow of ecosystem services, and through the drivers of change that affect ecosystems either as consequence of using the services or as indirect impacts due to human activities in general (Figure 2). More arrows linking the different elements of the framework and more detail in each of its elements can be added for specific purposes by specific users if needed; some options are outlined below.

Ecosystems are shaped by the interaction of communities of living organisms with the abiotic environment. Biodiversity - the variety of all life on earth - plays a key role in the structural set-up of ecosystems which is essential to maintaining basic ecosystem processes and supporting ecosystem functions. Ecosystem functions are defined as the capacity or the potential to deliver ecosystem services. Ecosystem services are, in turn, derived from ecosystem functions and represent the realized flow of services for which there is demand. For the purpose of this framework, ecosystem services also encompass the goods derived from ecosystems[18]. People benefit from ecosystem (goods and) services. These benefits are, among others, nutrition, access to clean air and water, health, safety, and enjoyment and they affect (increase) human wellbeing which is the key target of managing the socio-economic systems. The focus on benefits implies that ecosystem services are open to economic valuation. However, not all benefits to people from ecosystems can be measured in monetary terms. Therefore, it

[17] DPSIR: Driving forces – Pressures – State – Impact – Responses. This framework is used to structure thinking about the interplay between the environment and socio-economic activities.

[18] The distinction between goods and services as used in UK NEA (9) is still under discussion; see also (21)

is important to include other values as well, such as health value, social value or conservation value. The governance of the coupled socio-economic-ecological system is an integral part of the framework: Institutions, stakeholders and users of ecosystem services affect ecosystems through direct or indirect drivers of change. Policies concerning natural resource management aim to affect drivers of change to achieve a desired future state of ecosystems. Many other policies also affect these drivers and thus can be added to the framework as they have an impact on ecosystems even though they might not target them at all (e.g. through the construction of buildings or infrastructure, or industrial policy through pollution).

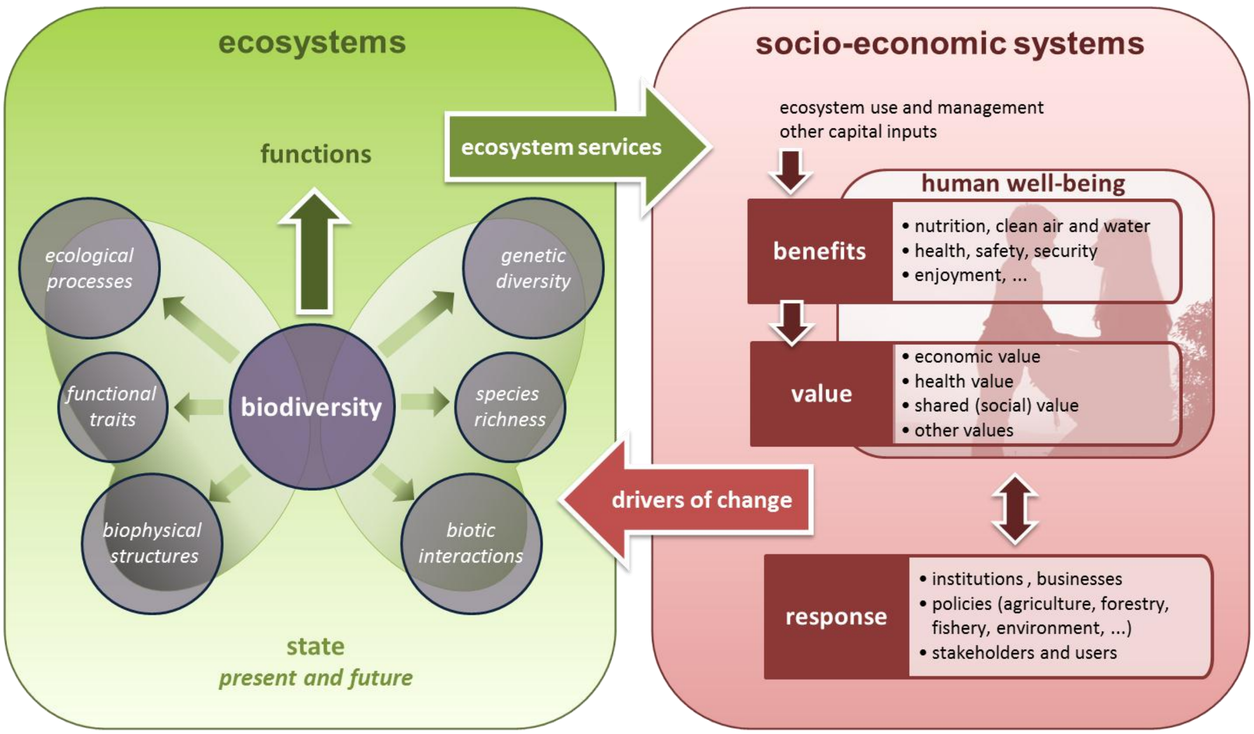

Figure 2. Conceptual framework for EU wide ecosystem assessments.

See also Annex 1: Glossary of terms.

The state of ecosystems is specifically addressed in the framework (Figure 2). The argument is that healthy ecosystems (in good status) possess the full potential of ecosystem functions. Ecosystem management and other capital inputs refer to the labour, capital or energy investments needed to obtain certain benefits (e.g. to harvest a crop, or to construct and maintain hiking trails for recreation). These measures influence ecosystems in a way to improve the delivery of a certain service (e.g. food production function and landscape beauty) often at the cost of other services which ecosystems are or could be delivering (e.g. regulating services), or at the cost of the state of ecosystems (e.g. lowering biodiversity level).

The framework can also help to structure information for policy support. If a policy intends to improve the state of ecosystems and biodiversity different types of information are useful:

- Information on the current state of ecosystems and/or the services they currently deliver as a baseline against which targets for improvement can be defined.
- Information on current management practices and how these affect ecosystems as well as how they should be modified in order to improve the target values, and
- Information on how policy can influence relevant management practices.
- Finally, for following up on the implementation and success of policies, monitoring of all of the above.

3.2 The role of biodiversity in supporting ecosystem functions and services

The first and foremost target of the EU Biodiversity Strategy to 2020 is to increase the efforts to achieve favourable conservation status of threatened habitats and species by completing the Natura 2000 network and by ensuring good management practises in the included protected areas. The second target of restoring ecosystems and maintaining their services builds on the premise that ecosystem services are dependent on biodiversity. And there is indeed mounting evidence demonstrating the dependency of specific ecosystem services and ecosystem functions on biodiversity (8-10).

Figure 3 elaborates on the different roles of biodiversity in supporting ecosystem functions and ecosystem services. The butterfly depicts six dimensions of biodiversity, three on each wing, which connect biodiversity to ecosystem functioning and ecosystem services.

The left wing contains three dimensions of biodiversity that contribute to ecosystem functioning.

i. Biodiversity enhances the efficiency of ecological processes such as primary production and decomposition. These processes are key determinants of ecosystem functions.

ii. Functional diversity, which is the variation in the degree of the expression of multiple functional traits, is a second important determinant of ecosystem functioning. Functional traits are those that define species in terms of their ecological roles - how they interact with the environment and with other species. For instance, the body size of pollinator species and their different tolerance to a minimum temperature increase the distance range and the temperature interval, respectively, for which wild pollination of crops can take place.

iii. Biodiversity, in particular plant species diversity, has an important role in structuring habitats, ecosystems and landscapes which is necessary for many other species, and hence ecosystem services, to exist.

The right wing of the butterfly contains three dimensions of biodiversity that contribute to ecosystem functioning but, importantly, which also directly deliver ecosystem services.

i. Genetic diversity is the diversity of the gene pool of single species. Both different varieties and wild crop and livestock relatives are considered crucial to maintain a genetically diverse stock as this diversity makes food production systems more resilient against future environmental change or diseases – the probability that some varieties are adapted to future conditions increases with diversity.

ii. Species richness (or the total number of species) and taxonomic diversity (the total number of species of certain groups, e.g. the total number of mammals) is often used as indicator for biodiversity. Species richness provides a direct benefit, in particular for people who enjoy bird watching, observing large vertebrates or collecting flowers or invertebrate species such as butterflies, beetles or spiders.

iii. The diversity of specific biotic interactions in a food web or in species networks such as predation and foraging provides in some cases a regulating service. Bees, when foraging on nectar carrying plants, help pollinate agricultural crops. Predatory insects help keep pests on agricultural crops under control.

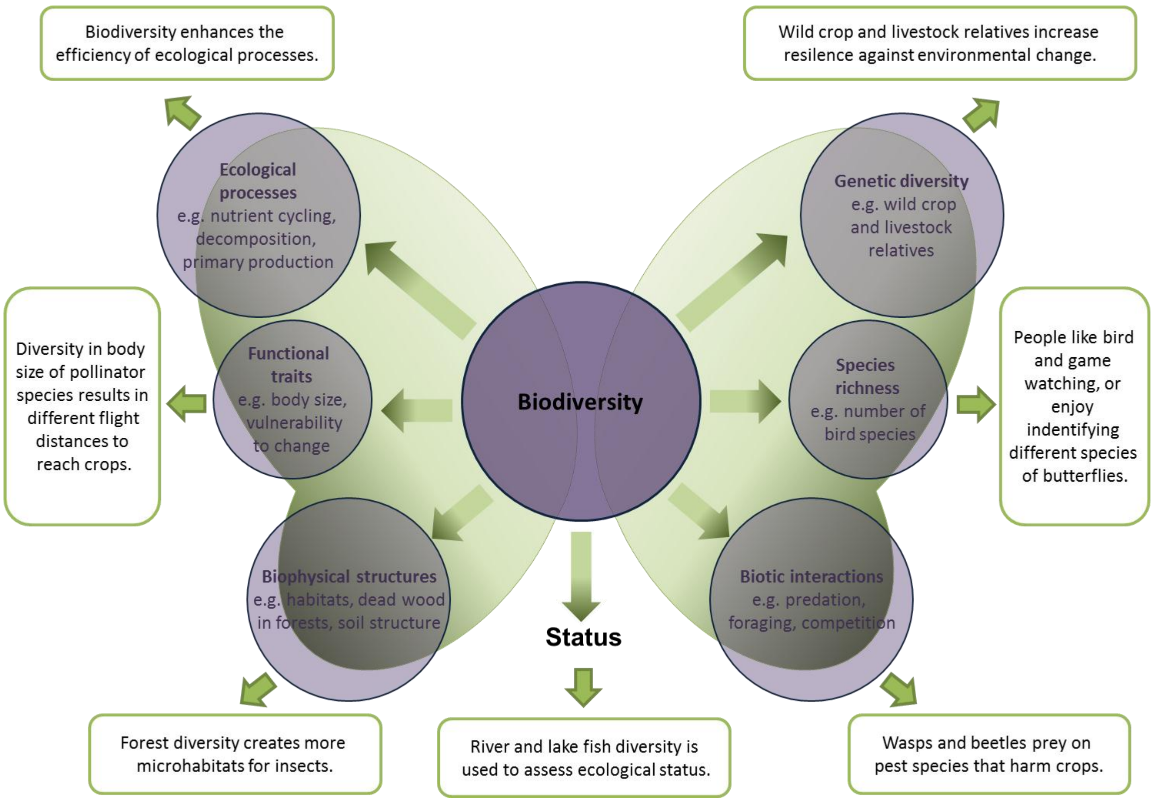

Figure 3. The multi-faceted role of biodiversity to support the delivery of ecosystem services and to assess the status of ecosystems. Biodiversity has multiple roles in relation to the delivery of ecosystem services and represents therefore a central component of the framework depicted in Figure 2.

The structural and functional metrics that are used to assess the potential of ecosystems to provide services and to determine the levels of services that are provided as benefits to humans can also be used to assess the health or state of ecosystems (20). For instance, the trophic structure of fish communities, particular traits such as migration and fish body size as well as fish species richness are used to assess the ecological status of surface waters as required under the Water Framework Directive (WFD). In the EU, legislation to protect the environment focuses in fact on improving the status of ecosystems. In particular, the EU aims to bring habitats and threatened species into favourable conservation status, freshwater and coastal ecosystems into good or high ecological status and marine ecosystems into good or high environmental status. Mainstreaming ecosystem services in EU policies that focus on the protection of terrestrial, freshwater or marine ecosystems assumes that there is a connection between ecosystem state and the services they deliver, which is also made explicit in the framework.

Connecting biodiversity to ecosystem state but also to particular ecosystem functions and ecosystem services entails thus defining multivariate combinations of these different dimensions of biodiversity and using them for mapping and assessment.

3.3 Defining ecosystem functions and services

The framework distinguishes ecosystem functions from the fundamental ecological processes, traits and structures that are supported by biodiversity. Functions here are constituted by different combinations of processes, traits and structures and represent the potential that ecosystems have to deliver services, irrespective whether or not they are useful for humans (21)[19]. Ecosystem functions therefore warrant a separate place in the conceptual framework.

In contrast to ecosystem functions, ecosystem services imply access and demand by humans. Healthy or pristine ecosystems and wilderness areas, to which we assign a high ecological status, are highly functional but may provide less ecosystem services than less pristine ecosystems placed near large population centres, simply because there is very little demand for it (*e.g.* a remote Scandinavian forest may deliver less recreational services than a green urban area). Yet, nearly pristine ecosystems are key and fragile components of the European environment, they may deliver other important services (e.g. lifecycle maintenance or carbon sequestration), and many stakeholders put a very high social value on them. It is therefore important to include a comprehensive set of services and value dimensions in ecosystem assessments.

3.4 Human well-being

The box on human well-being in Figure 2 is unpacked in three components: benefits, values and response. Benefits are positive changes in our well-being from the fulfilment of our needs and wants. Well-being depends substantially, but not exclusively, on ecosystem services (6). Here only four top level categories are included: nutrition, health, safety, and enjoyment which can all be delivered by multiple ecosystem services. This list is indicative and may require further specifications in a given context, and perhaps its own typology. The transition from benefits to values is complex in the real world of appreciation by humans, depending on location, relative scarcity, time in life, or cultural background. This too is understandably simplified in the diagram, but may have to be further developed and analysed depending on context and purpose of the analysis. Action 5 specifies one such context “to include the value of ecosystem services in national accounts by 2020”.

Monetary valuation of ecosystem services usually relies on the analyses of demand (beneficiaries) and the application of economic valuation techniques and ideally involves all relevant stakeholders. However, valuations can also be expressed in human health units, or biophysical terms. There are different methods to determine

[19] This paper uses the terminology of the TEEB study. Ecosystem functions represent the potential that ecosystems have to deliver a service which in turn depends on ecological structures and processes. For example, primary production (process) is needed to maintain a viable fish population (function) which can be used (harvested) to provide food (service). Possible confusion comes from the fact that many authors use the terms function and process interchangeably. We refer to reference (19).

shared social values, most of them discursive and with involvement of stakeholders and/or the general public. When analysing demand it is important to consider that it is scale dependent, as some services can be 'transported' over long distances (*e.g.* food provision) while others have a local level demand (*e.g.* soil protection).

The response box contains the stakeholders who are affected by the provision of ecosystem services either as providers or beneficiaries, or because they would have to change land use or other management practices affecting ecosystems and their services. Institutions refer to the current set of rules and regulations, both formal and informal, and the policies concern all policies affecting ecosystems either directly or indirectly, implicitly or explicitly. Also the business community and the private sector is an essential partner if we want to achieve biodiversity targets. All of these elements can be relevant at different levels from the EU level to the national, subnational and local level. Depending on the policy question these will need to be identified and analysed.

3.5 Ecosystem management and other capital inputs

The flow of services from ecosystems as benefits to people does not come for free. Ecosystem services in order to be beneficial and valuable to humans normally require additional investments (*e.g.* energy, labour, management) by humans. The energy content of ecosystem services is therefore in almost all cases a combination of natural (ecosystem processes based) energies and human based energies. Therefore, these inputs are also explicitly addressed in the framework.

Even the simplest of provisioning services such as wild food gathering requires harvesting labour. All cultural services (by definition) involve human action to absorb (and process) the information involved. The group of regulating services is diverse in this respect. They are in principle free flowing (e.g. climate regulation by carbon sequestration; air pollution capture) without human labour, but in economic terms there are at least opportunity costs involved, e.g. by having the forested land not available for urban activities or these services are substituting human investments such as flood protection by forests instead of by artificial infrastructure.

3.6 Typologies of ecosystems and ecosystem services

While the framework is valid for any ecosystem type and classification of services a specific assessment or mapping endeavour will have to decide how to classify ecosystems and their services. As outlined a broad range of questions and uses are potentially relevant and the priorities of Member States also vary. In order to ensure consistency and allow for aggregation or comparison of results across the EU there is thus a need to use common classifications and to define which ecosystems and services will be considered as a priority by Member States. Section 4 of this paper proposes the different types of ecosystems to be considered in this assessment. Section 5 proposes a typology for ecosystem services to be included.

4 A TYPOLOGY OF ECOSYSTEMS FOR MAPPING

4.1 Mapping ecosystems

An ecosystem is usually defined as a complex of living organisms with their (abiotic) environment and their mutual relations. Although this definition applies to all hierarchical levels (from a single water drop with its microorganisms to Earth's biomes), for the practical purposes of mapping and assessment, an ecosystem is here considered at the scale of habitat/biotope or landscape. A practical approach to the 'spatial delimitation of an ecosystem' is to build up a series of overlays of significant factors, mapping the location of discontinuities, such as in the distribution of organisms, the biophysical environment (soil types, drainage basins, depth in a water body), and spatial interactions (home ranges, migration patterns, fluxes of matter). A useful ecosystem boundary is the place where a number of these relative discontinuities coincide. Ecosystems within each category share a suite of biological, climatic, and social factors that tend to differ across categories. More specifically, there generally is greater similarity within than between each ecosystem type in:

- climatic conditions;
- geophysical conditions;
- dominant use by humans;
- surface cover (based on type of vegetative cover in terrestrial ecosystems or on fresh water, brackish water, or salt water in aquatic ecosystems);
- species composition;
- resource management systems and institutions.

The EU Habitats Directive does not define ecosystems but natural habitats. Natural habitats mean terrestrial or aquatic areas distinguished by geographic, abiotic and biotic features, whether entirely natural or semi-natural.

Ecosystem mapping is the spatial delineation of ecosystems following an agreed ecosystem typology (ecosystem types), which strongly depends on mapping purpose and scale. Mapping in the broader sense may also include mapping of status (including functioning and health) as the result of monitoring and assessment of the ecosystem's quality but in many cases this is considered to be object of ecosystem assessments.

Global approaches to ecosystem classification and mapping (or reporting) apply two basic principles: typological and regional (or their combination). The typological approach divides nature into ecosystem types – classes that can occur at more geographical locations (i.e., temperate broadleaf and mixed forests). The regional approach describes ecosystems from a regional (spatially unique) perspective (e.g., Dinaric mixed forests).

Ecosystem mapping also has to satisfy a management perspective and is largely determined by data availability. In the absence of an agreed and regularly updated European ecosystem map, the task of mapping could be interpreted as aggregation of proxy spatial information that describes as good as possible the biophysical complex on the ground surface and adequate representation in freshwater bodies and the seas. Such mapping should aim at providing quantitative aspects of the 'state of ecosystems', such as their distribution and extent.

For practical purposes, mainly triggered by data availability, and because of the strong links to the emerging Copernicus (previously known as GMES) land monitoring services, the proposed method of ecosystem mapping is based on the EU Biodiversity 2010 Baseline approach. This implies that CORINE Land Cover (CLC) classes as monitored in Copernicus are aggregated into ecosystem types for the purposes of MAES, in the most meaningful way possible to represent broad-scale ecosystems, and combined with ecosystem-relevant information. This aggregation is based on detailed expert analysis of relationships between land cover classes and habitat classification systems (i.e. EUNIS) to ensure consistency between these approaches.

4.2 Typology

The selection of broad habitat types or ecosystems that can be assessed for their status and their contribution in delivering ecosystem services needs to be carefully chosen to ensure both a balanced representation of important European ecosystems and meaningful aggregation of current continental or national land and marine unit(s) as well as of habitats that are listed under Annex I of the Habitats Directive and the predominant and special habitat types of the Marine Strategy Framework Directive. Following the EU 2010 Biodiversity Baseline, the proposed ecosystem classification shown in Table 3 is based on a combination of CLC classes for spatial explicit mapping adjusted with the European Nature Information System (EUNIS) habitat types where necessary.

The proposal for level 1 and 2 (Table 3) corresponds directly with the EUNIS habitat classification and SEBI 04 indicator on ecosystem coverage. It is relevant for EU policies and it is compatible with global ecosystem classifications. It is typological (enabling comparison between different parts of the Europe's territory), keeps a pan-European scale and takes into consideration regular mapping aspects (applying CLC data for spatial delineation). Given the importance of the CLC dataset for mapping terrestrial ecosystems and land use accounts, the Annex 2 provides a table with the correspondence between the ecosystem typology and the CLC level 3 classes.

Proposal 1 – Ecosystem typology for mapping

The ecosystem types in Table 3 are proposed as basic units for ecosystem mapping at European scale. These main classes should allow for consistent assessments of state and services from local to national, regional and European scale. Information from a more detailed classification and at higher spatial resolution should be compatible with the European-wide classification and could be aggregated in a consistent manner if needed. If required, aggregated sub-/trans-national classes such as 'mountainous areas' or 'coastal zones' can be generated using the proposed ecosystem types as a baseline set of mapping/assessment units.

The present typology separates at level 1 three major ecosystems: terrestrial systems, fresh water and the marine environment. It also anticipates the different reporting schemes of the environmental directives (HD, WFD, MSFD) and the implemented typologies. The following paragraphs provide a brief description of proposed ecosystem types.

4.2.1 Terrestrial ecosystems

The terrestrial ecosystems as delineated from Corine Land Cover classification and map are subdivided into urban systems, cropland, grassland, woodland and forest, heathland and shrub, sparsely vegetated land and wetlands.

- **Urban ecosystems** are areas where most of the human population lives and it is also a class significantly affecting other ecosystem types. Urban areas represent mainly human habitats but they usually include significant areas for synanthropic species, which are associated with urban habitats. This class includes urban, industrial, commercial, and transport areas, urban green areas, mines, dumping and construction sites.
- **Cropland** is the main food production area including both intensively managed ecosystems and multifunctional areas supporting many semi- and natural species along with food production (lower intensity management). It includes regularly or recently cultivated agricultural, horticultural and domestic habitats and agro-ecosystems with significant coverage of natural vegetation (agricultural mosaics).
- **Grassland** covers areas dominated by grassy vegetation (including tall forbs, mosses and lichens) of two kinds – managed pastures and (semi-)natural (extensively managed) grasslands.
- **Woodland and forest** are areas dominated by woody vegetation of various age or they have succession climax vegetation types on most of the area supporting many ecosystem services.
- **Heathland and shrub** are areas with vegetation dominated by shrubs or dwarf shrubs. They are mostly secondary ecosystems with unfavourable natural conditions. They include moors, heathland and sclerophyllous vegetation.
- **Sparsely or unvegetated land** are all unvegetated or sparsely vegetated habitats (naturally unvegetated areas). Often these ecosystems have extreme natural conditions that might support particular species. They include bare rocks, glaciers and dunes, beaches and sand plains.
- **Inland wetlands** are predominantly water-logged specific plant and animal communities supporting water regulation and peat-related processes. This class includes natural or modified mires, bogs and fens, as well as peat extraction sites.

4.2.2 Freshwater ecosystems

Freshwater ecosystems include at level 2 one single class:

- **Rivers and lakes** which are the permanent freshwater inland surface waters. This class includes water courses and water bodies.

4.2.3 Marine ecosystems

The typology of marine ecosystems reduces the 3-dimensional structure of the ocean to the 2 dimensions of the seabed (benthic) habitats, attributing the 3rd dimension, the water column (pelagic habitats), to depth zones. Brackish water and marine ecosystems in the land-sea interface are grouped together in a single type.

- **Marine inlets and transitional waters** are ecosystems on the land-water interface under the influence of tides and with salinity higher than 0.5 ‰. They include coastal wetlands, lagoons, estuaries and other transitional waters, fjords and sea lochs as well as embayments.
- The **coastal areas** refer to coastal, shallow, marine systems that experience significant land-based influences. These systems undergo diurnal fluctuations in temperature, salinity and turbidity, and are subject to wave disturbance. Depth is between 50 and 70 m.
- The **shelf** refers to marine systems away from coastal influence, down to the shelf break. They experience more stable temperature and salinity regimes than coastal systems, and their seabed is below wave disturbance. They are usually about 200 m deep.

- The **open ocean** refers to marine systems beyond the shelf break with very stable temperature and salinity regimes, in particular in the deep seabed. Depth is beyond 200 m.

The marine ecosystem typology is generally applicable across European waters (and globally) and also relates with the use of the marine environment by different sectors, which will help the assessment of ecosystem services delivered by marine ecosystems.

Table 3 presents an ecosystem typology which covers terrestrial, freshwater and marine habitats. However, data coverage for the different level 1 type ecosystems is uneven. In contrast to terrestrial and freshwater ecosystems, marine ecosystems and their services are largely overlooked and increasing efforts are needed to map the contributions of marine systems to the provision of ecosystem services (22). It is therefore important to stress that the typology of marine ecosystems may undergo further changes during the MAES assessment depending on the increasing availability of marine data[20] as well as on the relations between marine ecosystems and the services they provide. The present typology ignores the import role of the photic zone (under influence of light) which drives the functioning of marine food webs. Using the photic limit as additional criterion can in a later phase be introduced for both pelagic and benthic habitats as derived from EUSeaMap light penetration data. This allows a more accurate zoning per individual marine region, in particular of the shallow Baltic Sea and recognizes the importance of primary productivity as the basis for the marine food chain and so for marine ecosystem services. Introducing the photic limit in the typology requires a link to the MSFD zones, which is not straightforward and has not been undertaken at the moment.

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[20] The marine ecosystem typology grouped benthic and pelagic habitats into a single ecosystem type. The existing European scheme for consistent seabed mapping (EUSeaMap for benthic broad scale habitats) is currently operational only for selected parts of the 4 European/MSFD marine regions and full cover will not achieved before end of 2014. Coastal wetlands, lagoons and estuaries are available in the Corine Landcover dataset, which implies the mapping of geographically distinct entities, as done for lakes and rivers, rather than ecologically relevant mapping. This would be possible where EuSeaMap is available, which can map the benthic elements of some of the ecosystems in this type, i.e. of estuaries, fjords/sea lochs and embayments, and which – by rough approximation only – could also relate to the joint pelagic/benthic system. Thus, there is currently no European scheme allowing consistent mapping of the marine water column (pelagic habitats) neither of combined pelagic/benthic ecosystems. In terms of marine ecosystem definition and mapping, the operationalization of the marine ecosystem typology will require cross-walks between the marine EUNIS, the EUSeaMap and the MSFD habitat type classifications. This is necessary in order to link to existing national or regional assessments and maps, when those are not based on the MSFD predominant habitats. At the European level, these cross-walks will be carried out by the EEA's European Topic Centre on Biological Diversity (ETC BD) in 2013. ETC BD will also work towards clarifying the links between the Habitats Directive coastal and marine habitat types and the MSFD predominant habitat types. This is needed *inter alia* to fully benefit from Article 17 mapping and/or assessment information, which could be used, in particular, to assess 'habitat-based' marine ecosystem services. The correspondence between the photic zone and the MSFD zones remains to be investigated.

Table 3. Typology of ecosystems.
Refinement of the EU 2010 Biodiversity Baseline (EEA 2012)

Major eco-system category (level 1)	Ecosystem type for mapping and assessment (level 2)	Representation of habitats (functional dimension by EUNIS)/MSFD for marine ecosystems)	Representation of land cover (spatial dimension)	Benefits of mapping	Problems of mapping	Listed as ecosystems, major habitat types or reporting categories in	Spatial data availability
Terrestrial	**Urban**	Constructed, industrial and other artificial habitats	Urban, industrial, commercial and transport areas, urban green areas, mines, dump and construction sites	Urban areas represent mainly human habitats but they usually include significant areas for synanthropic species	CLC's coarse resolution that needs to be complemented e.g. by Urban atlas (ca. 300 cities) and HRL Imperviousness but see (23)	EUNIS (SEBI) UNEP/CBD* MA‡	CLC Urban Atlas HRL Imperviousness
	Cropland	Regularly or recently cultivated agricultural, horticultural and domestic habitats	Annual and permanent crops	Main food production areas, intensively managed ecosystems	Habitat classification (e.g. EUNIS) includes permanent crops into Heathland and scrub	EUNIS (SEBI, Baseline) UNEP/CBD MA	CLC
	Grassland	Grasslands and land dominated by forbs, mosses or lichens	Pastures and (semi-) natural grasslands	Areas dominated by grassy vegetation of two kinds – managed pastures and natural (extensively managed) grasslands	Distinction between intensively used and more natural grasslands requires additional datasets (Art. 17)	EUNIS (SEBI, Baseline) UNEP/CBD WWF+ MA	CLC HRL grasslands
	Woodland and forest	Woodland, forest and other wooded land	Forests	Climax ecosystem type on most of the area supporting many ecosystem services	Missing information on quality and management requires additional datasets (Art. 17, HRL forest)	EUNIS (SEBI, Baseline) UNEP/CBD WWF MA	CLC HRL forests (EFDAC)
	Heathland and shrub	Heathland, scrub and tundra (vegetation dominated by shrubs or dwarf shrubs)	Moors, heathland and sclerophyllous vegetation	Mostly secondary ecosystems with unfavourable natural conditions	Mapping the condition of these areas requires combination with Art.17	EUNIS (SEBI, Baseline) WWF MA	CLC
	Sparsely vegetated land	Unvegetated or sparsely vegetated habitats (naturally unvegetated areas)	Open spaces with little or no vegetation (bare rocks, glaciers and beaches, dunes and sand plains included)	Ecosystems with extreme natural conditions that might support valuable species. Includes coastal ecosystems on (beaches, dunes) affected by marine ecosystems	Becomes a conglomerate of distinctive rarely occurring ecosystems, often defined by different geographical location	EUNIS (SEBI, Baseline) UNEP/CBD MA	CLC

Major eco-system category (level 1)	**Ecosystem type for mapping and assessment (level 2)**	**Representation of habitats (functional dimension by EUNIS)/MSFD for marine ecosystems)**	**Representation of land cover (spatial dimension)**	**Benefits of mapping**	**Problems of mapping**	**Listed as ecosystems, major habitat types or reporting categories in**	**Spatial data availability**
	Wetlands	Mires, bogs and fens	Inland wetlands (marshes and peatbogs)	Specific plant and animal communities, water regulation, peat-related processes	Separation from grasslands (temporary inundation) and forests (tree canopy), HRL wetlands	EUNIS (SEBI, Baseline) UNEP/CBDMA	CLC HRL wetlands
Fresh water	**Rivers and lakes**	Inland surface waters (freshwater ecosystems)	Water courses and bodies incl. coastal lakes (without permanent connection to the sea)	All permanent freshwater surface waters	Underestimation of water courses and small water bodies needs application of external datasets (ECRINS, (HRL Small lakes)	EUNIS (SEBI, Baseline) WWF MA	CLC HRL small water bodies ECRINS
Marine†	**Marine inlets and transitional waters**	Pelagic habitats: Low/reduced salinity water (of lagoons) Variable salinity water (of coastal wetlands, estuaries and other transitional waters) Marine salinity water (of other inlets) Benthic habitats: Littoral rock and biogenic reef Littoral sediment Shallow sublittoral rock and biogenic reef Shallow sublittoral sediment	Coastal wetlands: Saltmarshes, salines and intertidal flats Lagoons: Highly restricted connection to open sea, reduced, often relatively stable, salinity regime Estuaries and other transitional waters: Link rivers to open sea, variable, highly dynamic salinity regime. All WFD transitional waters included Fjords/sea lochs: Glacially derived, typically elongated and deep; marine salinity regime Embayments: Non-glacial origin, typically shallow, marine salinity system Pelagic habitats in this type include the photic zone, benthic habitats can include it or not	Spatial representation of the land-sea interface, and of the relative proportion of habitats and related services. Interface limited by the WFD landward boundaries of transitional and coastal waters	Use of relevant CLC classes would lead to mapping geographically distinct entities rather than benthic habitats EUSeaMap†† provides broad-scale seabed habitat maps, which are based on predictive modelling with partial validation. But these cannot be used for all ecosystems in this class	EUNIS (SEBI, Baseline) UNEP/CBC WWF MA WFD transitional water bodies MSFD water column predominant habitat types: Variable salinity (estuarine), Reduced salinity and Marine salinity MSFD's seabed predominant habitats	CLC (allows mapping of lagoons, saltmarshes, salines, intertidal flats and estuaries) GIS layer of WFD lake water bodies and transitional water bodies EUSeaMap is now only available for the Baltic, North, Celtic and western Mediterranean seas. Remaining seas to be covered by new projects (over 2013-2014) Marine water column habitats are not mapped by EUSeaMap

Major eco-system category (level 1)	Ecosystem type for mapping and assessment (level 2)	Representation of habitats (functional dimension by EUNIS)/MSFD for marine ecosystems)	Representation of land cover (spatial dimension)	Benefits of mapping	Problems of mapping	Listed as ecosystems, major habitat types or reporting categories in	Spatial data availability
	Coastal	Pelagic habitats: Coastal waters Benthic habitats: Littoral rock and biogenic reef Littoral sediment Shallow sublittoral rock and biogenic reef Shallow sublittoral sediment	Coastal, shallow-depth marine systems that experience significant land-based influences. These systems undergo diurnal fluctuations in temperature, salinity and turbidity, and are subject to wave disturbance. Depth is up to 50-70 meters. Pelagic habitats in this type include the photic zone, benthic habitats can include it or not	Spatial representation of the marine coastal zone and of the relative proportion of habitats and related services	No European common scheme exists for mapping of pelagic habitats nor for combined pelagic/benthic systems EUSeaMap broad-scale seabed habitat maps are based on predictive modelling with partial validation	WFD coastal water bodies MSFD's water column predominant habitats with marine salinity MSFD's seabed predominant habitats	GIS layer of WFD coastal water bodies EUSeaMap is now only available for the Baltic, North, Celtic and western Mediterranean seas. Remaining seas to be covered by new projects (over 2013-2014) Marine water column habitats are not mapped by EUSeaMap
	Shelf	Pelagic habitats: Shelf waters Benthic habitats: Shelf sublittoral rock and biogenic reef Shelf sublittoral sediment	Marine systems away from coastal influence, down to the shelf slope. They experience more stable temperature and salinity regimes than coastal systems, and their seabed is below wave disturbance. Depth is up to 200 meters. Pelagic habitats in this type include the photic zone, benthic habitats are beyond the photic limit (aphotic)	Spatial representation of the marine shelf zone and of the relative proportion of habitats and related services	No European common scheme exists for mapping of pelagic habitats nor for combined pelagic/benthic systems EUSeaMap broad-scale seabed habitat maps are based on predictive modelling with partial validation	MSFD's water column predominant habitats with marine salinity MSFD's seabed predominant habitats	EUSeaMap is now only available for the Baltic, North, Celtic and western Mediterranean seas. Remaining seas to be covered by new projects (over 2013-2014) Marine water column habitats are not mapped by EUSeaMap
	Open ocean	Pelagic habitats: Oceanic waters Benthic habitats: Bathyal (upper, lower) rock and biogenic reef Bathyal (upper, lower) sediment Abyssal rock and biogenic reef Abyssal sediment	Marine systems beyond the shelf slope with very stable temperature and salinity regimes, in particular in the deep seabed. Depth is beyond 200 meters. Pelagic habitats in	Spatial representation of the marine open ocean zone and of the relative proportion of habitats and related services	No European common scheme exists for mapping of pelagic habitats nor for combined pelagic/benthic systems EUSeaMap broad-scale seabed habitat	MSFD's water column predominant habitats with marine salinity MSFD's seabed predominant habitats	EUSeaMap is now only available for the Baltic, North, Celtic and western Mediterranean seas. Remaining seas to be covered by new projects (over

Major eco-system category (level 1)	**Ecosystem type for mapping and assessment (level 2)**	**Representation of habitats (functional dimension by EUNIS)/MSFD for marine ecosystems)**	**Representation of land cover (spatial dimension)**	**Benefits of mapping**	**Problems of mapping**	**Listed as ecosystems, major habitat types or reporting categories in**	**Spatial data availability**
			this type are, in proportion, mostly aphotic, benthic habitats are aphotic		maps are based on predictive modelling with partial validation		2013-2014) Marine water column habitats are not mapped by EUSeaMap

† Partially under development until mid-2013
‡ MA's type may differ to our description (http://millenniumassessment.org/documents/document.300.aspx.pdf)
* UNEP/CBD only partially covering/mentioning (http://www.cbd.int/doc/meetings/sbstta/sbstta-10/information/sbstta-10-inf-10-en.pdf)
+ WWF – Global Ecoregions (http://wwf.panda.org/about_our_earth/ecoregions/about/)
†† http://jncc.defra.gov.uk/page-5020
HRL: High Resolution Layer

5 A TYPOLOGY OF ECOSYSTEM SERVICES

5.1 Classification of ecosystem services

Three international classification systems are available to classify ecosystem services: MA, TEEB and CICES. In essence, they relate to a large extent to each other; all three include provisioning, regulating and cultural services. The correspondence between these classifications is illustrated in Table 4. Each classification has its own advantages and disadvantages due to the specific context within which they were developed.

MA. The Millennium Ecosystem Assessment (MA) was the first large scale ecosystem assessment and it provides a framework that has been adopted and further refined by TEEB and CICES. The MA organises ecosystem services into four well known groups:

1. provisioning services
2. regulating services
3. cultural services
4. supporting services

TEEB. TEEB proposes a typology of 22 ecosystem services divided in 4 main categories, mainly following the MA classification:

1. provisioning services
2. regulating services
3. habitat services
4. cultural and amenity services

An important difference TEEB adopted was the omission of supporting services, which are seen in TEEB as a subset of ecological processes. Instead, habitat services have been identified as a separate category to highlight the importance of ecosystems to provide habitat for migratory species (e.g. as nurseries) and gene-pool “protectors” (e.g. natural habitats allowing natural selection processes to maintain the vitality of the gene pool). The availability of these services is directly dependent on the status of the habitat (habitat requirements) providing the service. In case commercial species are involved, such as fish and shrimp species which spawn in estuarine and coastal nursery areas but of which adults are caught far away, this service has an economic (monetary) value in its own right. Also the importance of the gene-pool protection service of ecosystems is increasingly recognized, both as “hot spots” for conservation (in which money is increasingly invested) and to maintain the original gene-pool of commercial species (which we are increasingly imitating through the creation of botanic gardens, zoos and gene banks).

CICES. The Common International Classification of Ecosystem Services offers a structure that links with the framework of the UN System of Environmental-Economic Accounts (SEEA 2003) which is currently being revised with a volume on ecosystem (capital) accounts to be published in the first half of 2013. CICES builds on the existing classifications but focusses on the ecosystem service dimension. In the CICES system services are either provided by living organisms (biota) or by a combination of living organisms and abiotic processes. ***Abiotic*** outputs and services, e.g. provision of minerals by mining or the capture of wind energy, can affect ecosystem services but they do not rely on living organisms for delivery. They are therefore considered as part of overall natural capital (which comprises sub-soil assets, abiotic flows and ecosystem capital and services). The individual types of natural capital possess different key characteristics (e.g. renewable or not) that translate into specific management challenges. Figure 4 summarises some of the key distinctions between the different types of natural capital.

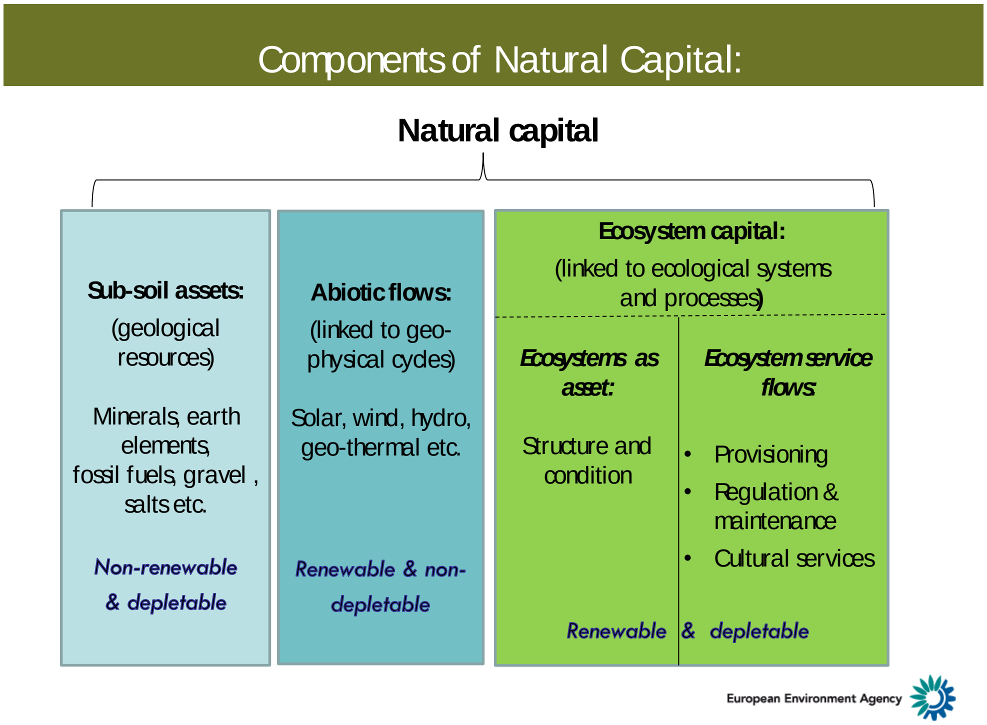

Figure 4. The main components of natural capital can be divided into 3 major components: ecosystem capital as combination of biotic and abiotic factors, non-renewable abiotic assets such as fossil fuels and non-depletable abiotic resources such wind and solar energy.

Maintaining ecosystem capital stocks and functions is essential to ensure continued production of the flows of ecosystem services that societies and economies benefit from every day. The ecosystem capital accounts being developed by the EEA aim to estimate the increase or decrease in the availability or supply of ecosystem services as well as the underlying status of ecosystems that determine their functioning.

Table 4. Ecosystem services categories in MA, TEEB and CICES

MA categories	**TEEB categories**		**CICES v4.3 group**[†]
Food (fodder)	Food	**Provisioning services**	Biomass [Nutrition]
			Biomass (Materials from plants, algae and animals for agricultural use)
Fresh water	Water		Water (for drinking purposes) [Nutrition]
			Water (for non-drinking purposes) [Materials]
Fibre, timber	Raw Materials		Biomass (fibres and other materials from plants, algae and animals for direct use and processing)
Genetic resources	Genetic resources		Biomass (genetic materials from all biota)
Biochemicals	Medicinal resources		Biomass (fibres and other materials from plants, algae and animals for direct use and processing)
Ornamental resources	Ornamental resources		Biomass (fibres and other materials from plants,

MA categories	TEEB categories		CICES v4.3 group[†]
			algae and animals for direct use and processing)
			Biomass based energy sources
			Mechanical energy (animal based)
Air quality regulation	Air quality regulation	**Regulating services (TEEB)** **Regulating and supporting services (MA)** **Regulating and maintenance services (CICES)**	[Mediation of] gaseous/air flows
Water purification and water treatment	Waste treatment (water purification)		Mediation [of waste, toxics and other nuisances] by biota
			Mediation [of waste, toxics and other nuisances] by ecosystems
Water regulation	Regulation of water flows		[Mediation of] liquid flows
	Moderation of extreme events		
Erosion regulation	Erosion prevention		[Mediation of] mass flows
Climate regulation	Climate regulation		Atmospheric composition and climate regulation
Soil formation (supporting service)	Maintenance of soil fertility		Soil formation and composition
Pollination	Pollination		Lifecycle maintenance, habitat and gene pool protection
Pest regulation	Biological control		Pest and disease control
Disease regulation			
Primary production Nutrient cycling (supporting services)	Maintenance of life cycles of migratory species (incl. nursery service)		Lifecycle maintenance, habitat and gene pool protection
			Soil formation and composition
			[Maintenance of] water conditions
	Maintenance of genetic diversity (especially in gene pool protection)		Lifecycle maintenance, habitat and gene pool protection
Spiritual and religious values	Spiritual experience	**Cultural services**	Spiritual and/or emblematic
Aesthetic values	Aesthetic information		Intellectual and representational interactions
Cultural diversity	Inspiration for culture, art and design		Intellectual and representational interactions
			Spiritual and/or emblematic
Recreation and ecotourism	Recreation and tourism		Physical and experiential interactions
Knowledge systems and educational values	Information for cognitive development		Intellectual and representational interactions
			Other cultural outputs (existence, bequest)
MA provides a classification that is globally recognised and used in sub global assessments.	*TEEB provides an updated classification, based on the MA, which is used in on-going national TEEB studies across Europe.*		*CICES provides a hierarchical system, building on the MA and TEEB classifications but tailored to accounting.*

[†] Explanatory information from CICES division level [between squared brackets] and from CICES class level (between parentheses).

5.2 CICES

The use of a common classification, i.e. CICES, in mapping, assessment and accounting would provide an integrated and holistic perspective. The original aim for developing CICES was to facilitate the more consistent approach for constructing information and data bases for ecosystem accounts (24). However, the need to integrate ecosystem mapping, environmental accounting and economic valuation and the potential benefits this can deliver has led to the classification providing a useful platform for the characterization and assessment of ecosystem services.

Proposal 2 – Ecosystem services categories

The general framework developed by CICES is proposed to be used for the integration of values of ecosystems in accounting frameworks so that cross-reference can be made between ecosystem services and the other instruments for environmental accounting mentioned above. The CICES classification is considered to provide a flexible and hierarchical classification that can be adapted to the specific situation and needs of Member States.

For the purposes of CICES, ecosystem services are defined as the contributions that ecosystems make to human well-being. They are seen as arising from living organisms (biota) or the interaction of biotic and abiotic processes, and refer specifically to the 'final' outputs or products from ecological systems. That is, the things directly consumed, used or enjoyed by people. Following common usage, the classification recognises these outputs to be provisioning, regulating and cultural services, but it does not cover the so-called 'supporting services' originally defined in the MA. The supporting services are treated as part of the ecosystem processes and ecosystem functions that characterise ecosystems (Figure 2). Since they are only indirectly consumed or used, and may simultaneously facilitate the output of many 'final outputs', it was considered that they were best dealt within environmental accounts, in other ways.

CICES has a five level hierarchical structure (section – division – group – class – class type). The more detailed class types makes the classification more user-friendly and provides greater clarification on what ecosystem services are included within each class. Using a five-level hierarchical structure is in line with United Nations Statistical Division (UNSD) best practice guidance as it allows the five level structure to be used for ecosystem mapping and assessment, while the first four levels can be employed for ecosystem accounting without reducing the utility of the classification for different users.

At the highest level are the three familiar sections of provisioning, regulating and maintenance, and cultural; below that are nested eight divisions of services. This basic structure is shown in Table 4, which also illustrates how the CICES grouping of services relates to the classification used in TEEB (7).

Table 4 shows that it is relatively straightforward to cross-reference the TEEB categories with CICES. The labels used in CICES have been selected to be as generic as possible, so that other more specific or detailed categories can progressively be defined, according to the interests of the user. Thus the TEEB categories 'raw materials', 'genetic', 'medicinal' and 'ornamental' resources clearly link to the CICES 'materials division' but correspond in terms of breadth more to the 'class' or 'class type' level in CICES.

The structure for CICES below the division level is shown in Annex 3, with twenty 'service groups' and forty eight 'service classes' being proposed. Table 5 provides the formal definitions of the service themes and classes and the rationale that underpins them. Definitions need to be developed for all the levels in the classification.

Several features of the structure of the CICES classification scheme should be noted.

- Abiotic environmental outputs which often affect ecosystems and their services are not included in the approach: If ecosystems are defined in terms of the interaction between living organisms and their abiotic environment then it could be argued that the generation of an ecosystem service must involve living organisms (i.e. show dependency on biodiversity). According to this strict definition, abiotic environmental outputs, such as salt, wind and snow, for example, are not included but are addressed in a separate 'complementary classification table'.

- The 'regulation and maintenance' section includes 'habitat services': The main difference between the CICES and TEEB classifications is in the treatment of 'habitat services'. While TEEB identifies them as a distinct grouping at the highest level, CICES regards them as part of a broader 'regulating and maintenance' section. It is proposed that they form a group including classes that capture aspects of ecosystem capital that are important for the regulation and maintenance of 'biotic' conditions in ecosystems (e.g. pest and disease control, pollination, gene-pool protection etc.), and are equivalent to other biophysical factors that regulate the ambient conditions such as climate regulation.
- The service descriptors become progressively more specific at lower levels: A key feature of the classification is its hierarchical structure. The feedback gained during previous consultations on CICES suggested that the naming of the higher levels should be as generic and neutral as possible. Thus 'flow regulation' is suggested, for example, as opposed to 'hazard regulation'. The assumption is that users would then identify the specific services that they are dealing with as 'classes' and 'class types', and use the hierarchal structure to show where the focus of their work lies, or aggregate measurement into the broader groupings for reporting or for making comparisons.

Table 5. Definitions of service themes and classes used in CICES v4.3[21]

Provisioning services	Includes all material and biota-dependent energy outputs from ecosystems; they are tangible things that can be exchanged or traded, as well as consumed or used directly by people in manufacture. Within the provisioning service section, three major divisions of services are recognised: • Nutrition includes all ecosystem outputs that are used directly or indirectly as foodstuffs (including potable water) • Materials (biotic) that are used directly or employed in the manufacture of goods • Energy (biomass) which refer to biotic renewable energy sources and mechanical energy provided by animals Provisioning of water is either attributed to nutrition (drinking) or materials (industrial etc.). It is considered as ecosystem service because its amount and quality is at least partly steered by ecosystem functioning. For this reason seawater is not included. The provisioning services groups are further divided in classes and class types.
Regulating and maintenance services	Includes all the ways in which ecosystems control or modify biotic or abiotic parameters that define the environment of people, i.e. all aspects of the 'ambient' environment. These are ecosystem outputs that are not consumed but affect the performance of individuals, communities and populations and their activities. Within the regulating and maintenance section, three major service divisions are recognised: • Mediation of waste, toxics and other nuisances: the services biota or ecosystems provide to detoxify or simply dilute substances mainly as a result of human action • Mediation of flows (air, liquid, solid masses): this covers services such as regulation and maintenance of land and snow masses, flood and storm protection • Maintenance of physical, chemical, biological conditions: this recognises that ecosystems provide for sustainable living conditions, including soil formation, climate regulation, pest and disease control, pollination and the nursery functions that habitats have in the support of provisioning services. All the regulation and maintenance divisions are further divided into service groups, classes and class types.

[21] Revised version of Common International Classification of Ecosystem Services (CICES v4.3), 17 January 2013; http://cices.eu/

	The hierarchical classification allows these to be distinguished by type of process and media.
Cultural services	Includes all non-material ecosystem outputs that have symbolic, cultural or intellectual significance Within the cultural service section, two major divisions of services are recognised: • Physical and intellectual interactions with biota, ecosystems, and land-/seascapes • Spiritual, symbolic and other interactions with biota, ecosystems, and land-/seascapes The two cultural divisions can be broken down further into groups, classes and class types. The hierarchical classification allows these to be distinguished using criteria such as whether it involves physical or intellectual activity.

6 TOWARDS AN ECOSYSTEM ASSESSMENT

6.1 What is understood by an ecosystem assessment

An ecosystem assessment as required for the implementation of the Biodiversity Strategy to 2020 needs to provide both an analysis of the natural environment by looking at the state of biodiversity and ecosystems (ecosystem assessment in sensu stricto) and by evaluating the level of ecosystem services provided to people (ecosystem service assessment). It needs to consider both the ecosystems from which the services are derived and also the people who depend on and are affected by changes in the supply of services, thereby connecting environmental and development sectors (25). Ecosystem assessments, such as the MA and several sub-global assessments that followed the MA, are carried out at multiple temporal, spatial and policy scales (26, 27).

In line with the MA approach, the objective of Action 5 is to provide a critical evaluation of the best available information for guiding decisions on complex public issues. It is not a research activity per se but will benefit from on-going and future related research projects funded by EU and MS. This dimension will therefore be given consideration as well.

The ecosystem assessment(s) that will be carried out under Action 5 need thus to be based on a synthesis of the relevant information of biodiversity, ecosystems and ecosystem services at different spatial scales in such a way that the assessment will ultimately provide answers to the key policy questions that were listed in Section 2 of the paper.

The framework that is outlined in Section 3 of this paper can integrate different sorts of information which are relevant for an ecosystem assessment:

- The state of biodiversity and ecosystems in Europe,
- The flow of ecosystem services from ecosystems to society to enhance human wellbeing,
- The value changes associated with changes in ecosystem service supply, and
- Plausible scenarios and outlooks for social and economic change across Europe that have positives or negative impacts on biodiversity, ecosystems and their services.

The typology of ecosystems (Section 4) and the typology of ecosystem services (Section 5) provide the analytical frame (matrix) for an ecosystem assessment (Figure 4). To operationalize Action 5 of the EU 2020 Biodiversity Strategy in a pragmatic and sequential manner the MAES working group has identified four main strands of work:

I. Biophysical baseline mapping and assessment of the status of major ecosystems;
II. Biophysical baseline mapping and assessment of defined ecosystem services;
III. Alignment of ecosystem service assessments with scenarios of future changes (future outlooks), developed together with policy makers and stakeholders to ensure their salience and legitimacy and consequently the use of the results in decision making;

IV. Valuation of ecosystem services for baseline and contrasting scenarios and integration into environmental and economic accounting.

The first two tasks have to be performed in priority and are therefore the key focus of this paper while the third and fourth tasks have to be completed by 2020.

In the short-term, the essential challenge of Action 5 is to make the best use of and to collate the current information and scientific knowledge available on ecosystems and their services in Europe. Importantly, the knowledge base must be accessible to Member States for mapping and assessment in their territory. The work to be undertaken under Action 5 will strongly build on the outcomes of the MA and TEEB studies. It will also capitalise on the experience and newly developed knowledge from on-going assessments[22]. We mention as examples the recently finished national ecosystem assessments of the UK, Portugal and Spain. At EU level, a European ecosystem assessment will benefit from the integrated outcomes of the reporting obligations of the Member States under EU environmental legislation such as Habitats and Bird Directive, Water Framework Directive, Marine Strategy Framework Directive, Air Quality Directive, etc. on the status of biotic components of ecosystems (i.e. ecological status of water bodies, conservation status of protected species and habitat types and environmental status of the marine environment) and abiotic environmental conditions such as air quality including greenhouse gas emissions, surface water, groundwater and marine water quantity and physico-chemical quality. This information will need to be complemented with more detailed information and case-studies provided by the Member States and stakeholders in a coherent manner.

In addition to on-going national assessments and reporting, several research initiatives at European scale have addressed (RUBICODE[23] (28, 29), ATEAM[24] (30), ALARM[25]) or address the mapping and assessment of ecosystem services. In particular, we mention VOLANTE[26], PRESS, the JRC led PEER initiative on mapping ecosystem services (31), the FOREST EUROPE initiative on valuation of forest ecosystem services[27] and on-going research activities on forest ecosystem services and on ecosystem fragmentation/connectivity at the JRC (FOREST Action[28]).

The review of status and, in general, the work undertaken within MAES WG by Member States and EU institutions on assessments of ecosystems, ecosystem services, mapping and valuation would be an important contribution to and benefit from the IPBES (Intergovernmental Platform on Biodiversity and Ecosystem Services) Intersessional Process.

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22 http://biodiversity.europa.eu/ecosystem-assessments/assessments

23 http://www.rubicode.net/rubicode/index.html

24 http://www.pik-potsdam.de/ateam/

25 http://www.alarmproject.net/alarm/

26 http://www.volante-project.eu/

27 http://www.foresteurope.org/

28 http://forest.jrc.ec.europa.eu/

6.2 Biophysical baseline mapping and assessment of major ecosystems

Member States are committed to report on the conservation status of habitats and species, the ecological status of water bodies and the environmental status of marine waters, in the period 2012-2014. This quasi synchronised reporting will be integrated as much as possible as part of the streamlining initiative of EU Policies on Biodiversity, Nature, Water and Marine environment, currently being discussed between the Commission and the Member States at respective Directors meetings. Other regular reporting processes provide relevant data and information for describing the status of ecosystem functioning - such as air quality, statistical data about agricultural yields, timber, etc. including through the reporting to the UN Conventions. In December 2010, the Environment Council requested that the Commission and Member States enhance and enforce the implementation of environment legislation in order to improve the state of the environment and ensure a level playing field. The response of the Commission to that request is to improve the delivery of benefits from EU environment measures by building confidence through better knowledge and responsiveness (32).

Additional information is also available (but not necessarily accessible) from national and European activities, especially Copernicus and research projects. At the European scale, these data represent a primary data source for assessing the state of ecosystems. Most environmental data sets from national reporting are made available by European bodies such as the European Environment Agency (EEA) in cooperation with EIONET and the European Topic Centres (ETCs), Eurostat, JRC, and DG Environment through the Environmental Data Centres and Information Systems. Environment-relevant data and information is also available in other EC services and related agencies (e.g. International Council for the Exploration of the Sea - ICES for marine information).

Proposal 3 – Mapping and assessing the status of major ecosystems

EEA and DG Environment are currently assessing data availability and methods for ecosystem mapping and assessment at European scale. As soon as the ecosystem classification is adopted, guidelines and recommendations will be developed in close collaboration with the Member States and distributed for review and comments.

6.3 Biophysical baseline mapping and assessment of defined ecosystem services

Research on mapping and assessment of ecosystem services is increasing. As a result of different methodological approaches, different sets of indicators are being used to assess individual services, resulting in different units in which ecosystem services are expressed. For example, different proxies are often used to study air quality regulation including fluxes in atmospheric gases between vegetation and the air, atmospheric cleaning capacity of vegetation or levels of pollutants in the air. These discrepancies evidently have implications for estimating monetary values. Thus, the need to standardize definitions for each service and methods for mapping them is important in comparing results among different Members States and measuring effectiveness of different policy measures. Consistency in mapping approaches is therefore a major challenge.

A first important step to such a standard approach is provided by the thematic working group on mapping ecosystem services of the Ecosystem Services Partnership (ESP)[29], the worldwide network to enhance the science and practical application of ecosystem services assessment. This working group presented a blueprint for mapping and modelling ecosystem services (33), which contains a set of standard attributes for recording ecosystem service mapping and modelling studies. The blueprint provides a template and checklist of information needed for those carrying out a modelling and mapping ecosystem service study and it will contribute, over time, to a database of completed blueprints that is expected to become a valuable information resource of methods and information used in previous modelling and mapping studies.

Several approaches to mapping ecosystem services exist and reviews of methodologies are available (4, 22, 34-39).

- Deriving information on ecosystem services directly from land-use/cover or habitat maps (40). Such approaches may be appropriate at national or European scales, for areas where the dominant service relates directly to land use (e.g. crop and timber production) or where data availability or expertise is limited, and where the focus is on the assumed presence of ecosystem services rather than on quantification of the supply. This method is often coupled to value transfer. Ecosystem service values are transferred from existing valuation studies to other areas using land cover data for value transfer (41). This approach cannot be so easily applied to the marine environment.

- Primary data to map ecosystem services are used for provisioning services where statistics are available. Examples include timber, food, or water supply. Statistical data usually relate to certain administrative units. For the EU assessment, valuable socio-economic data may be extracted from national and EU reports/datasets (e.g. Eurostat, national statistics from MS). Socio-economic analysis linked to environmental assessments can be also obtained from the sources of information mentioned in the previous section (e.g. Water Framework Directive Art. 9, visitors to Natura 2000 sites).

- Primary data are often not available for regulating and cultural services and we must rely on proxies for mapping these services. For instance, the regulation of urban air quality by trees depends much on the size and density of the leaves. A dense canopy is able to capture more particulate matter or pollutants than sparse canopies. The leaf area index is therefore a possible indicator to map this ecosystem service.

- Recent mapping techniques are based on biological data such as functional traits of plants or ecosystem structure and habitat data (42). Functional traits, such as vegetation height, leaf dry matter content, leaf nitrogen and phosphorus concentration, flowering onset, can be used to map several services (43). Habitat classification, such as the European Nature Information System (EUNIS) classification include detailed data on the associated biodiversity, which makes their use reasonable in mapping relationships between biodiversity and ecosystem services.

[29] http://www.es-partnership.org/esp

- The mapping of ecosystem services should also be carried out in the view of contributing to the establishment of a Green Infrastructure for Europe. Green Infrastructure includes issues of ecosystem connectivity and fragmentation which analysis needs to be integrated into ecosystem services mapping. Tools and indicators developed at JRC (44) can be useful in this frame.
- Models and derived indicators: For instance InVEST (45) or ARIES[30] or any other biophysical/ecological model that can be adapted to map ecosystem services as well. The JRC develops European scaled models for mapping ecosystem services for instance in collaboration with the PEER network under the PRESS project (31). The mapping exercise of ecosystem services is often conducted per ecosystem and per service and the cross-sectoral analysis of ecosystem services in terms of their synergies and the need for trade-off need to be further addressed.

Proposal 4 – Mapping ecosystem services

The MAES working group should overview the drafting of methodological guidelines on mapping ecosystem services. These guidelines should include a flexible set of indicators for mapping ecosystem services as well as mapping tools, methodologies and training options.

6.4 Outlook and valuation

An outlook or scenario analysis showing the implications for biodiversity and ecosystem services of different possible futures is an essential component of an ecosystem assessment. Contrasting policy scenarios with baseline changes that arise from policy measures can be valued in terms of change in well-being. Valuation and outlook using scenarios are foreseen to be carried out after 2014. The way they will be implemented in the assessment will be discussed then. Several activities and research projects are working on methods and tools to provide the necessary instruments.

- At EEA, Quickscan[31] is currently being developed as a decision support tool that enables the construction and visualisation of different land use futures in a spatially explicit manner.
- JRC and EEA are evaluating valuation methods regarding their applicability for national and European assessments.
- The FP7 projects VOLANTE, OpenNESS and OPERAS develop tools for biophysical, economic and social assessments of ecosystem services (see Box 3).

30 Artificial Intelligence for Ecosystem Services: http://www.ariesonline.org

31 QUICKScan: A pragmatic approach for bridging gaps in the science-policy interface; Manuel Winograd (European Environment Agency), Marta Perez-Soba (ALTERRA), Peter Verweij (ALTERRA), Rob Knappen (ALTERRA), LIAISE OPEN DAY, Bilbao, Spain, 14 March, 2012.

- JRC develops an integrated modelling tool coupling the land use modelling platform to the delivery of ecosystem services and changes in biodiversity at regional scale.

Box 3. European research projects under the 7th framework program that can contribute to MAES.

OpenNESS – Operationalisation of Natural Capital and Ecosystem Services. OpenNESS aims to translate the concepts of Natural Capital (NC) and Ecosystem Services (ES) into operational frameworks that provide tested, practical and tailored solutions for integrating ES into land, water and urban management and decision-making. It examines how the concepts link to, and support, wider EU economic, social and environmental policy initiatives and scrutinizes the potential and limitations of the concepts of ES and NC. http://www.openness-project.eu/

OPERAs – Operational Potential of Ecosystem Research Applications. OPERAs aims to improve understanding of how applying ES/NC concepts in managing ecosystems contributes to human well-being in different social-ecological systems in inland and coastal zones, in rural and urban areas, related to different ecosystems including forests and fresh water resources. http://operas-project.eu

VOLANTE - Visions of Land use Transitions in Europe. VOLANTE provides an interdisciplinary scientific basis to inform land use and natural resource management policies and decision-making. It is achieving this by advancing knowledge in land system science and using this knowledge to develop a roadmap for future land resource management in Europe. http://www.volante-project.eu

EU BON – Building the European Biodiversity Observation Network. EU BON is part of the Group on Earth Observation's Biodiversity (GEO BON) and will deliver a comprehensive "European Biodiversity Portal" for all stakeholder communities and strategies http://www.eubon.eu/

7 NEXT STEPS

Given the tight timeframe within which Action 5 needs to be implemented, there is an urgent need to prioritize the work to be done at a first stage. An all-embracing, standardized ecosystem assessment covering all types of ecosystems and all types of services across the Member States may not be realistic. As outlined in the EEA survey on ecosystem assessments in Europe conducted in 2010 and regularly updated, there is diversity of approaches and activities among countries. We need shared and consistent methods applied for a limited set of ecosystem services allowing for cross-comparison and provision of guidance based on pitfalls/best practice from Member States. Some Member States rather focus on selected ecosystems and key ecosystem services for which data are available or provide specific case studies (ground-truth) which should all contribute to the overall EU picture.

This was indeed one the conclusions of the first MAES workshop of November 2012 which aimed to inform Member States and stakeholders of the progress and relevance of the work of the Working Group on Mapping and Assessment of Ecosystems and their Services (MAES), and to discuss how this process could be supported and strengthened at EU and national level. The main conclusions of the workshop were:

- There was a general agreement that MAES is needed and that its scope goes much further than the support to Target 2 (to maintain and restore ecosystems and their services) of the EU 2020 Biodiversity Strategy. In line with the 7th Environment Action Programme, MAES will contribute to improving the confidence of policy-makers in the evidence-based approach to policy, prioritising investment, facilitating the understanding of complex environmental and societal challenges.
- The potential added value that such a process would bring to policy-making in general needs to be more prominent and widely communicated. In February 2013, a letter has been sent from Director Pia Bucella to the Nature Directors in all Member States to underline the importance of the MAES activity and asking the Nature Directors to continue their support for the MAES work. A high-level event to present the first MAES delivery and communicate the importance of MAES for policy-making is planned for 22 May 2014.
- MAES should help consolidate implementation of environmental legislation and build on the data delivered by existing reporting processes and information system associated with the nature legislation, Water Framework Directive and Marine Strategy Framework Directive. The integration of knowledge gained from these data remains a major challenge that the MAES Working Group should address and ensure that the outcomes are converted into metrics that are relevant to Target 2.
- MAES will also require access to relevant information and knowledge from other sectors such as agriculture and forestry. This will involve much more coordination at EU and national level.
- Also, the need for providing guidance and sharing of experience was strongly requested. It was clear that MAES will be a long-term process that now needs to be operationalized through a phased and adaptive approach where EU and Member States would need to join forces. A priority for the work under MAES will be to identify short term deliveries to be undertaken jointly.

Following the workshop it was decided to test the analytical framework outlined in this paper using six thematic pilots:

1. A pilot will focus on the use of information reported under the Nature Directives (e.g. Article 17 of the Habitats Directive) and how this information can be used for the assessment of ecosystem condition. The results from this pilot will be relevant for assessing all ecosystems;

Four pilots include broad ecosystem types:

2. Agro-ecosystems (cropland and grassland);
3. Forest ecosystems;
4. Freshwater ecosystems (rivers, lakes and wetlands);
5. Marine ecosystems;

Finally, there will be a pilot to explore the challenge of valuation:

6. Natural capital accounting.

Further pilots might be developed at a later stage of the process (e.g. urban ecosystems).

Box 4. Next steps

1. Steps to be taken at EU and Member States' level to map and assess ecosystems and their services, such as through the establishment of an EU high-level scientific advisory board and national MAES working groups as already done by some MS.

2. Assistance required by the Member States to map and assess ecosystems and their services, such as through the development of guidelines, methodologies, indicators, establishment of ad hoc expert groups, web platform for information sharing (BISE).

3. Steps to be taken at EU and MS level for the work to be undertaken jointly, such as through the sharing of responsibilities, identification of pilots, provision of case-studies to steer the work on ecosystem services delivered by nature (using Article 17 data), forest ecosystems (e.g. carbon sequestration), agro-ecosystems (making use of agri-environmental data and statistics), freshwater (in relation to ecological status), the marine environment, and natural capital accounting.

4. Strengthening of environment policy-science interface at EU and Member States' level to fill knowledge gaps, such as through support of syntheses of current knowledge, investment in further research and involvement of scientific community through mechanisms building on existing institutions in connection with the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES).

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ABBREVIATIONS & ACRONYMS

Alter-Net:	A Long-Term Biodiversity, Ecosystem and Awareness Research Network
Art.17:	Article 17 (assessments of conservation status of habitats and species under the EU Habitats Directive))
CAP:	Common Agricultural Policy
CAPRI:	Common Agricultural Policy Regionalised Impact Modelling System
CBD:	Convention on Biological Diversity
CGBN:	Co-ordination Group for Biodiversity and Nature
CICES:	Common International Classification of Ecosystem Services
CIF:	Common Implementation Framework of the biodiversity strategy
CLC:	Corine Land Cover
DG ENV:	Directorate-General for Environment
DG REGIO:	Directorate-General for Regional and Urban Policy
DG RTD:	Directorate-General for Research and Innovation
DOPA:	Digital Observatory on Protected Areas
DPSIR:	Drivers – Pressures – State – Impact - Response
EEA:	European Environment Agency
EIONET:	European Environment Information and Observation Network
ETC:	European Topic Centre
EU:	European Union
EUNIS:	European Nature Information System
EUROSTAT:	Statistical office of the European Union
GBIF:	Global Biodiversity Information Facility°
GEO-BON:	Global Earth Observation - Biodiversity Observation Network
GMES:	Global Monitoring for Environmental Security Program, now called Copernicus
HD:	Habitats Directive (Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora)
Horizon 2020:	The EU Framework Programme for Research and Innovation from 2014
HRL:	High Resolution Layer
ICES:	International Council for the Exploration of the Sea
IPBES:	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
JRC:	Joint Research Centre
MA:	Millennium Ecosystem Assessment
MAES:	Mapping and Assessment of the state of Ecosystems and their Services
MS:	EU Member States
MSFD:	Marine Strategy Framework Directive (Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy)
NUTS:	Nomenclature of territorial units for statistics
PEER:	Partnership for European Environmental Research
RIO +20:	United Nations Conference on Sustainable Development, 2012
SEBI:	Streamlining European Biodiversity Indicators
SEEA:	System of Environmental Economic Accounts (United Nations)
TEEB:	The Economics of Ecosystems and Biodiversity

UK-NEA:	National Ecosystem Assessment of the United Kingdom
UN:	United Nations
UNEP:	United Nations Environment Programme
UNEP-WCMC:	United Nations Environment Programme - World Conservation Monitoring Centre
UNSD:	United Nations Statistics Division
WFD:	Water Framework Directive (Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy)
WWF:	World Wide Fund for Nature

ANNEX 1: GLOSSARY OF TERMS

Assessment: The analysis and review of information for the purpose of helping someone in a position of responsibility to evaluate possible actions or think about a problem. Assessment means assembling, summarising, organising, interpreting, and possibly reconciling pieces of existing knowledge and communicating them so that they are relevant and helpful to an intelligent but inexpert decision-maker (Parson, 1995).

Assets: Economic resources (TEEB, 2010).

Benefits: Positive change in wellbeing from the fulfilment of needs and wants (TEEB, 2010).

Biodiversity: The variability among living organisms from all sources, including inter alia terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part, this includes diversity within species, between species, and of ecosystems (cf. Article 2 of the Convention on Biological Diversity, 1992).

Biophysical structure: The architecture of an ecosystem as a result of the interaction between the abiotic, physical environment and the biotic communities, in particular vegetation.

Biophysical valuation: A method that derives values from measurements of the physical costs (e.g., surface requirements, labour, biophysical processes, material inputs).

Conservation status (of a natural habitat): The sum of the influences acting on a natural habitat and its typical species that may affect its long-term natural distribution, structure and functions as well as the long-term survival of its typical species (EEC, 1992).

Conservation status (of a species): The sum of the influences acting on the species concerned that may affect the long-term distribution and abundance of its populations (EEC, 1992).

Drivers of change: Any natural or human-induced factor that directly or indirectly causes a change in an ecosystem. A direct driver of change unequivocally influences ecosystem processes and can therefore be identified and measured to differing degrees of accuracy; an indirect driver of change operates by altering the level or rate of change of one or more direct drivers (MA, 2005).

Ecological value: Non-monetary assessment of ecosystem integrity, health, or resilience, all of which are important indicators to determine critical thresholds and minimum requirements for ecosystem service provision (TEEB, 2010).

Economic valuation: The process of expressing a value for a particular good or service in a certain context (e.g., of decision-making) in monetary terms (TEEB, 2010).

Ecosystem assessment: A social process through which the findings of science concerning the causes of ecosystem change, their consequences for human well-being, and management and policy options are brought to bear on the needs of decision-makers (UK NEA, 2011).

Ecosystem degradation: A persistent reduction in the capacity to provide ecosystem services (MA, 2005).

Ecosystem function: Subset of the interactions between biophysical structures, biodiversity and ecosystem processes that underpin the capacity of an ecosystem to provide ecosystem services (TEEB, 2010).

Ecosystem process: Any change or reaction which occurs within ecosystems, physical, chemical or biological. Ecosystem processes include decomposition, production, nutrient cycling, and fluxes of nutrients and energy (MA, 2005).

Ecosystem service: The benefits that people obtain from ecosystems (MA, 2005). The direct and indirect contributions of ecosystems to human wellbeing (TEEB, 2010). The concept 'ecosystem goods and services' is synonymous with ecosystem services. The service flow in our conceptual framework refers to the actually used service.

Ecosystem state: The physical, chemical and biological condition of an ecosystem at a particular point in time.

Ecosystem status: A classification of ecosystem state among several well-defined categories. It is usually measured against time and compared to an agreed target in EU environmental directives (e.g. HD, WFD, MSFD).

Ecosystem: A dynamic complex of plant, animal, and microorganism communities and their non-living environment interacting as a functional unit (MA, 2005). For practical purposes it is important to define the spatial dimensions of concern.

Energy inputs: Subsidies added to ecosystems such as fertilizers, fossil fuel, or labour that are required to turn ecosystem functions into ecosystem services and benefits.

Functional traits: A feature of an organism that has demonstrable links to the organism's function.

Habitat: The physical location or type of environment in which an organism or biological population lives or occurs. Terrestrial or aquatic areas distinguished by geographic, abiotic and biotic features, whether entirely natural or semi-natural.

Human well-being: A context- and situation dependent state, comprising basic material for a good life, freedom and choice, health and bodily well-being, good social relations, security, peace of mind, and spiritual experience (MA, 2005).

Indicator: Observed value representative of a phenomenon to study. In general, indicators quantify information by aggregating different and multiple data. The resulting information is therefore synthesised.

Restoration: Refers to the process of actively managing the recovery of an ecosystem that has been degraded, damaged or destroyed as a means of sustaining ecosystem resilience and conserving biodiversity (CBD, 2012).

Socio-economic system: Our society (which includes institutions that manage ecosystems, users that use their services and stakeholders that influence ecosystems)

Value: The contribution of an action or object to user-specified goals, objectives, or conditions (MA, 2005).

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ANNEX 2: CORRESPONDENCE BETWEEN CORINE LAND COVER CLASSES AND ECOSYSTEM TYPES (TABLE 3)

CLC Level 1	CLC Level 2	CLC Level 3	Ecosystem types level 2
1. Artificial surfaces	1.1. Urban fabric	1.1.1. Continuous urban fabric	Urban
		1.1.2. Discontinuous urban fabric	
	1.2. Industrial, commercial and transport units	1.2.1. Industrial or commercial units	
		1.2.2. Road and rail networks and associated land	
		1.2.3. Port areas	
		1.2.4. Airports	
	1.3. Mine, dump and construction sites	1.3.1. Mineral extraction sites	
		1.3.2. Dump sites	
		1.3.3. Construction sites	
	1.4. Artificial non-agricultural vegetated areas	1.4.1. Green urban areas	
		1.4.2. Sport and leisure facilities	
2. Agricultural areas	2.1.Arable land	2.1.1. Non-irrigated arable land	Cropland
		2.1.2. Permanently irrigated land	
		2.1.3. Rice fields	
	2.2. Permanent crops	2.2.1. Vineyards	
		2.2.2. Fruit trees and berry plantations	
		2.2.3. Olive groves	
	2.3. Pastures	2.3.1. Pastures	Grassland
	2.4. Heterogeneous agricultural areas	2.4.1. Annual crops associated with permanent crops	Cropland
		2.4.2. Complex cultivation patterns	
		2.4.3. Land principally occupied by agriculture, with significant areas of natural vegetation	
		2.4.4. Agro-forestry areas	
3. Forests and semi-natural areas	3.1. Forests	3.1.1. Broad-leaved forest	Woodland and forest
		3.1.2. Coniferous forest	
		3.1.3. Mixed forest	
	3.2. Shrub and/or herbaceous vegetation association	3.2.1. Natural grassland	Grassland
		3.2.2. Moors and heathland	Heathland and shrub
		3.2.3. Sclerophyllous vegetation	
		3.2.4. Transitional woodland shrub	Woodland and forest
	3.3. Open spaces with little or no vegetation	3.3.1. Beaches, dunes, and sand plains	Sparsely vegetated land
		3.3.2. Bare rock	
		3.3.3. Sparsely vegetated areas	
		3.3.4. Burnt areas	
		3.3.5. Glaciers and perpetual snow	
4. Wetlands	4.1. Inland wetlands	4.1.1. Inland marshes	Wetlands
		4.1.2. Peatbogs	
	4.2. Coastal wetlands	4.2.1. Salt marshes	Marine inlets and transitional waters
		4.2.2. Salines	
		4.2.3. Intertidal flats	
5. Water bodies	5.1 Inland waters	5.1.1 Water courses	Rivers and lakes
		5.1.2 Water bodies	
	5.2 Marine waters	5.2.1 Coastal lagoons	Marine inlets and transitional waters
		5.2.2 Estuaries	
		5.2.3 Sea and ocean	Marine

ANNEX 3: CICES CLASSIFICATION VERSION 4.3

CICES for ecosystem service mapping and assessment					
CICES for ecosystem accounting				Note this section is open in that many class types can potentially be recognised and nested in the higher level classes, depending on the ecosystems being considered.	Note: this section is not complete and for illustrative purposes only. Key components could change by region or ecosystem.
Section	**Division**	**Group**	**Class**	**Class type**	**Examples**
This column lists the three main categories of ecosystem services	*This column divides section categories into main types of output or process.*	*The group level splits division categories by biological, physical or cultural type or process.*	*The class level provides a further sub-division of group categories into biological or material outputs and bio-physical and cultural processes that can be linked back to concrete identifiable service sources.*	*Class types break the class categories into further individual entities and suggest ways of measuring the associated ecosystem service output.*	
Provisioning	Nutrition	Biomass	Cultivated crops	*Crops by amount, type*	Cereals (e.g. wheat, rye, barely), vegetables, fruits etc.
			Reared animals and their outputs	*Animals, products by amount, type*	Meat, dairy products (milk, cheese, yoghurt), honey etc.
			Wild plants, algae and their outputs	*Plants, algae by amount, type*	Wild berries, fruits, mushrooms, water cress, *Salicornia* (saltwort or samphire); seaweed (e.g. *Palmaria palmata* = dulse, dillisk) for food
			Wild animals and their outputs	*Animals by amount, type*	Game, freshwater fish (trout, eel etc.), marine fish (plaice, sea bass etc.) and shellfish (i.e. crustaceans, molluscs), as well as equinoderms or honey harvested from wild populations; Includes commercial and subsistence fishing and hunting for food
			Plants and algae from *in-situ* aquaculture	*Plants, algae by amount, type*	*In-situ* seaweed farming
			Animals from *in-situ* aquaculture	*Animals by amount, type*	*In-situ* farming of freshwater (e.g. trout) and marine fish (e.g. salmon, tuna) also in floating cages; shellfish aquaculture (e.g. oysters or crustaceans) in e.g. poles
		Water	Surface water for drinking	*By amount, type*	Collected precipitation, abstracted surface water from rivers, lakes and other open water bodies for drinking
			Ground water for drinking		Freshwater abstracted from (non-fossil) groundwater layers or via

Section	Division	Group	Class	Class type	Examples
					ground water desalination for drinking
	Materials	Biomass	Fibres and other materials from plants, algae and animals for direct use or processing	*Material by amount, type, use, media (land, soil, freshwater, marine)*	Fibres, wood, timber, flowers, skin, bones, sponges and other products, which are not further processed; material for production e.g. industrial products such as cellulose for paper, cotton for clothes, packaging material; chemicals extracted or synthesised from algae, plants and animals such as turpentine, rubber, flax, oil, wax, resin, soap (from bones), natural remedies and medicines (e.g. chondritin from sharks), dyes and colours, ambergris (from sperm whales used in perfumes); Includes consumptive ornamental uses.
			Materials from plants, algae and animals for agricultural use		Plant, algae and animal material (e.g. grass) for fodder and fertilizer in agriculture and aquaculture;
			Genetic materials from all biota		Genetic material (DNA) from wild plants, algae and animals for biochemical industrial and pharmaceutical processes e.g. medicines, fermentation, detoxification; bio-prospecting activities e.g. wild species used in breeding programmes etc.
		Water	Surface water for non-drinking purposes	*By amount, type and use*	Collected precipitation, abstracted surface water from rivers, lakes and other open water bodies for domestic use (washing, cleaning and other non-drinking use), irrigation, livestock consumption, industrial use (consumption and cooling) etc.
			Ground water for non-drinking purposes		Freshwater abstracted from (non-fossil) groundwater layers or via ground water desalination for domestic use (washing, cleaning and other non-drinking use), irrigation, livestock consumption, industrial use (consumption and cooling) etc.
	Energy	Biomass-based energy sources	Plant-based resources	*By amount, type, source*	Wood fuel, straw, energy plants, crops and algae for burning and energy production

Section	Division	Group	Class	Class type	Examples
			Animal-based resources		Dung, fat, oils, cadavers from land, water and marine animals for burning and energy production
		Mechanical energy	Animal-based energy	*By amount, type, source*	Physical labour provided by animals (horses, elephants etc.)
Regulation & Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	Bio-remediation by micro-organisms, algae, plants, and animals	*By amount, type, use, media (land, soil, freshwater, marine)*	Bio-chemical detoxification / decomposition / mineralisation in land / soil, freshwater and marine systems including sediments; decomposition / detoxification of waste and toxic materials e.g. waste water cleaning, degrading oil spills by marine bacteria, (phyto)degradation, (rhizo)degradation etc.
			Filtration/sequestration/storage/accumulation by micro-organisms, algae, plants, and animals	*By amount, type, use, media (land, soil, freshwater, marine)*	Biological filtration / sequestration / storage / accumulation of pollutants in land / soil, freshwater and marine biota, adsorption and binding of heavy metals and organic compounds in biota
		Mediation by ecosystems	Filtration/sequestration/storage/accumulation by ecosystems	*By amount, type, use, media (land, soil, freshwater, marine)*	Bio-physicochemical filtration / sequestration / storage / accumulation of pollutants in land / soil, freshwater and marine ecosystems, including sediments; adsorption and binding of heavy metals and organic compounds in ecosystems (combination of biotic and abiotic factors)
			Dilution by atmosphere, freshwater and marine ecosystems		Bio-physico-chemical dilution of gases, fluids and solid waste, wastewater in atmosphere, lakes, rivers, sea and sediments
			Mediation of smell/noise/visual impacts		Visual screening of transport corridors e.g. by trees; Green infrastructure to reduce noise and smells
	Mediation of flows	Mass flows	Mass stabilisation and control of erosion rates	*By reduction in risk, area protected*	Erosion / landslide / gravity flow protection; vegetation cover protecting/stabilising terrestrial, coastal and marine ecosystems, coastal wetlands, dunes; vegetation on slopes also preventing avalanches (snow, rock), erosion protection of coasts and sediments by mangroves, sea grass, macroalgae, etc.

Section	Division	Group	Class	Class type	Examples
			Buffering and attenuation of mass flows		Transport and storage of sediment by rivers, lakes, sea
		Liquid flows	Hydrological cycle and water flow maintenance	*By depth/volumes*	Capacity of maintaining baseline flows for water supply and discharge; e.g. fostering groundwater; recharge by appropriate land coverage that captures effective rainfall; includes drought and water scarcity aspects.
			Flood protection	*By reduction in risk, area protected*	Flood protection by appropriate land coverage; coastal flood prevention by mangroves, sea grass, macroalgae, etc. (supplementary to coastal protection by wetlands, dunes)
		Gaseous / air flows	Storm protection	*By reduction in risk, area protected*	Natural or planted vegetation that serves as shelter belts
			Ventilation and transpiration	*By change in temperature/humidity*	Natural or planted vegetation that enables air ventilation
	Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Pollination and seed dispersal	*By amount and source*	Pollination by bees and other insects; seed dispersal by insects, birds and other animals
			Maintaining nursery populations and habitats	*By amount and source*	Habitats for plant and animal nursery and reproduction e.g. seagrasses, microstructures of rivers etc.
		Pest and disease control	Pest control	*By reduction in incidence, risk, area protected*	Pest and disease control including invasive alien species
			Disease control		In cultivated and natural ecosystems and human populations
		Soil formation and composition	Weathering processes	*By amount/concentration and source*	Maintenance of bio-geochemical conditions of soils including fertility, nutrient storage, or soil structure; includes biological, chemical, physical weathering and pedogenesis
			Decomposition and fixing processes		Maintenance of bio-geochemical conditions of soils by decomposition/mineralisation of dead organic material, nitrification, denitrification etc.), N-fixing and other bio-geochemical processes;
		Water conditions	Chemical condition of freshwaters	*By amount/concentration and source*	Maintenance / buffering of chemical composition of freshwater column and sediment to ensure favourable living conditions for biota e.g. by

Section	Division	Group	Class	Class type	Examples
					denitrification, re-mobilisation/re-mineralisation of phosphorous, etc.
			Chemical condition of salt waters		Maintenance / buffering of chemical composition of seawater column and sediment to ensure favourable living conditions for biota e.g. by denitrification, re-mobilisation/re-mineralisation of phosphorous, etc.
		Atmospheric composition and climate regulation	Global climate regulation by reduction of greenhouse gas concentrations	*By amount, concentration or climatic parameter*	Global climate regulation by greenhouse gas/carbon sequestration by terrestrial ecosystems, water columns and sediments and their biota; transport of carbon into oceans (DOCs) etc.
			Micro and regional climate regulation		Modifying temperature, humidity, wind fields; maintenance of rural and urban climate and air quality and regional precipitation/temperature patterns
Cultural	Physical and intellectual interactions with biota, ecosystems, and land-/seascapes [environmental settings]	Physical and experiential interactions	Experiential use of plants, animals and land-/seascapes in different environmental settings	*By visits/use data, plants, animals, ecosystem type*	*In-situ* whale and bird watching, snorkelling, diving etc.
			Physical use of land-/seascapes in different environmental settings		Walking, hiking, climbing, boating, leisure fishing (angling) and leisure hunting
		Intellectual and representational interactions	Scientific	*By use/citation, plants, animals, ecosystem type*	Subject matter for research both on location and via other media
			Educational		Subject matter of education both on location and via other media
			Heritage, cultural		Historic records, cultural heritage e.g. preserved in water bodies and soils
			Entertainment		Ex-situ viewing/experience of natural world through different media
			Aesthetic		Sense of place, artistic representations of nature
	Spiritual, symbolic and other interactions with biota, ecosystems, and land-/seascapes [environmental	Spiritual and/or emblematic	Symbolic	*By use, plants, animals, ecosystem type*	Emblematic plants and animals e.g. national symbols such as American eagle, British rose, Welsh daffodil
			Sacred and/or religious		Spiritual, ritual identity e.g. 'dream paths' of native Australians, holy places; sacred plants and animals and their parts

Section	Division	Group	Class	Class type	Examples
	settings]	Other cultural outputs	Existence	*By plants, animals, feature/ecosystem type or component*	Enjoyment provided by wild species, wilderness, ecosystems, land-/seascapes
			Bequest		Willingness to preserve plants, animals, ecosystems, land-/seascapes for the experience and use of future generations; moral/ethical perspective or belief

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