The tension between nature conservation and economic valuation of ecosystem services

Admiraal, J.F.

Chapter 3

The loss of biodiversity conservation in EU research programmes

J.F. Admiraal[1], C.J.M. Musters[1], G.R. de Snoo[1]

[1]Institute of Environmental Sciences CML, Leiden University, Einsteinweg 2, 2333 CC, Leiden

Published as:

Admiraal J.F., Musters C.J.M. & De Snoo G.R. 2016. The loss of biodiversity conservation in EU research programmes: Thematic shifts in biodiversity wording in the environment themes of EU research programmes FP7 and Horizon 2020. Journal for Nature Conservation 30: 12–18

Abstract

Society has been seeking ways to express biodiversity's value to stimulate its protection. Economic valuation of ecosystem services has had limited success to motivate biodiversity protection and reaching the EU 2020 biodiversity strategy targets is in danger of failure. The framing of biodiversity's value in policy documents thus becomes a topic of discussion, because it greatly influences the ways policy makers think about environmental problems. We present an analysis of the framing of biodiversity's value in the FP7 and Horizon 2020 work programs of the European Commission in the period of 2007 to 2014, and the projects accepted under these programs. We conclude first that biodiversity was lost as a topic in the transition from FP7 to Horizon 2020, accompanied by a three-quarters loss of biodiversity topics in the projects accepted under these work programs. Moreover, the use of 'ecosystem services' was 1.5 times higher at the end of that period compared to the beginning in the work programs, to the detriment of the use of 'sustainability' and 'conservation' which halved during that same period. In the light of international commitments to biodiversity conservation, the focus towards ecosystem services and away from conservation is of great concern.

Keywords:

Biodiversity conservation, economic valuation, ecosystem services, environmental policy, European Commission.

1. Introduction

As biodiversity in Europe is in degradation, scientists have been seeking ways to express its value to society (Wood 1997; Pimentel et al. 1997; De Groot et al. 2002). During the last two decades, it became popular in scientific and policy documents to express the value of biodiversity as ecosystem services and in money, in hopes of boosting our willingness to protect it (Costanza et al. 1997; Nunes & van den Bergh 2001; Losey & Vaughan 2006; Perrings et al. 2010; TEEB 2010). The economic value of ecosystem services is often calculated as being very high, but as a means to protect biodiversity its success is limited so far (Pearce 2007). Furthermore, the current expression of biodiversity's value in ecosystem services may in itself be a troubled development that hampers successful biodiversity conservation (Mace et al. 2012). Alternative expressions and incorporating frameworks of biodiversity's value have been proposed to address some of the shortcomings of the notion of ecosystem services (Mace 2014). The expression of biodiversity's value has thus become a topic of discussion.

The expression of biodiversity's values is of immediate concern in Europe because of uniquely European approaches to biodiversity conservation. European biodiversity conservation is frequently framed as an interactive partnership and a bottom-up approach between humans and nature, as explained by Boitani and Sutherland (2015), in which areas of conservation are human dominated agricultural landscapes and the species to be protected are dependent on human interference. This contrasts with the North American model in which a greater dualistic view is seen between nature and society. As food production and conservation overlap spatially and coexist in strong tension (Hodge et al. 2015), biodiversity conservation in Europe is therefore expected to feel a more immediate effect if the expression of the uses and values of biodiversity changes in society. In addition, biodiversity conservation and changes in expression of biodiversity's values in Europe acquire significance worldwide, because the tension between food production and conservation that underlies the European approaches is anticipated to increase in areas around the world. Therefore, a closer look at European experiences in biodiversity conservation may be beneficial for countries who are moving along a similar development path (Boitani and Sutherland 2015).

With the UN Convention on Biological Diversity Aichi targets in danger of being missed in the European Union (Tittensor et al. 2014; EC 2015; EEA 2015), a critical look is warranted at the expression of biodiversity's value in EU research frameworks that are in service of reaching these targets. Programmes of great influence in this regard are the EU Seventh Framework Research Programme (FP7) and the follow-up EU Framework Programme for Research and Innovation – Horizon 2020 – ,which influence the direction of scientific research in the European Union. Horizon 2020's open calls for research projects are in service of the EU 2020 biodiversity strategy (EP resolution 2014), which was in turn set up in response to a UN mandate to reach the UN Convention on Biological Diversity Aichi targets. In addition, Horizon 2020 compliments national efforts in scientific research by co-funding other subsidy networks such as BiodivERsA and the European Cooperation in Science and Technology (COST). Finally, the Horizon 2020 subsidy mechanisms are a direct communication from the European Commission to European scientists about desired research topics and the social and politic context that such research would be in service of.

Previous analyses of EU research programmes illuminate shared topics of accepted projects, but investigations of trends through time have been rare. Both the BiodivERsA database (BiodivERsA 2013) and the Biodiversity Information System for Europe (BISE 2011) aim to create clarity in the distribution of topics among accepted research projects of EU research programmes via a searchable database, but do not expand upon trends through the years. Trends through time that have been recognized in literature, however, give cause for concern. A trend has been identified by Matei et al. (2011), concluding that budget allocated to biodiversity-related projects in the Environment theme in FP7 has significantly decreased between 2007 and 2010. Similarly, an analysis of themes was presented on the abstracts of projects accepted under the European BiodivERsA research infrastructure from 2004 to 2011, concluding that research funded in Europe shifted focus from organismal and population levels to a focus on larger organizational levels such as ecosystems, with a changed emphasis on monetary costs and benefits of biodiversity protection (Gambette et al. 2014).

Our study builds on this by analyzing the visibility and recognition of biodiversity and its conservation in the wording of open call research subsidy documents of the EU. More precisely, trends in word use are traced for the open call descriptions on the topic of biodiversity conservation in the documents of the environment theme in the EU Seventh Framework Research Programme (FP7) from 2007-2013 and the EU Framework Programme for Research and Innovation - Horizon 2020 of 2014-2015. Our focus is on the prevalence of 'conservation' of biodiversity, and how this differs in prevalence from to other mentioned keywords related to biodiversity, such as 'ecosystem services'. This content analysis allows us to make inferences on thematic shifts underlying biodiversity conservation in the EU research programmes. Clarity on the trends of wording of biodiversity's value in EU research programmes is a necessary investigation to ensure a tight focus on efforts to halt biodiversity degradation in the EU.

2. Methods

We performed an analysis on the open call research descriptions of FP7 and Horizon 2020 work programs, focusing on the documents published as the thematic work program '*Environment (including climate change)'* from FP7 2007 to 2013 and its follow-up theme '*Climate action. environment. resource efficiency and raw materials'* from Horizon 2020, because these are most directly concerned with biodiversity conservation. Furthermore, the project objectives have been analyzed of projects that were accepted under these specific open calls. This would illuminate whether any trends we find in the open call descriptions of the work programmes are mirrored in the stated objectives of projects that are submitted to these open calls. For a complete explanation of the methods used, we refer to the supplementary materials. All FP7 and Horizon 2020 documents were retrieved from http://ec.europa.eu/research/index.cfm and http://cordis.europa.eu/projects/home_en.html.

First, the location of biodiversity as a topic in chapters and subchapters was traced in the structure of the work programs through the years as a reflection of its priority as a research subject. Secondly, we traced word use in the documents through the years. In this analysis we aimed to trace why biodiversity is considered important in the work programs and to what end. For the coding of words, first all places in the work programs where biodiversity or a related term is mentioned were identified, and then it was

noted manually which values were attached to it in the same paragraph. This procedure generated a list of values that was summarized in nine groups (Table S3). Then the visibility of the groups in the text was traced through the years by counting in the documents the words for the values. In addition to these nine groups, we traced referrals to 'costs and benefits' and 'stakeholder participation'. These referrals too can be seen as indicators of either a focus on economic valuation or a widening view on biodiversity values.

3. Results

3.1. Structure of the FP7 and Horizon 2020 work programs

The foremost observation regarding the structure of the FP7 documents is that biodiversity loss in itself is not a recognized topic at a high organizational level in the text, but that it is embedded five levels down within the structure (Table 1). FP7 has five different sections: *Cooperation*, *Ideas*, *People*, *Capacities* and *Euratom*; only in the *Cooperation* section are distinct research fields delineated. It has ten themes, and two themes in particular concern values of biodiversity: theme two, '*Food, agriculture and fisheries, and biotechnology'* and theme six, '*Environment (including climate change)*'. Each theme has subsections named *Activities* and these are further broken down into *Sub-Activities* and then into *Areas*, and on this level a specific focus on biodiversity can be found as part of *Area 6.2.1.4 Biodiversity* (Table 1).

Ideas
- European Research Council (ERC)

People
- Marie Curie Action

Capacities
- Reseach infrastructures (7 subchapters)

Euratom
- Euratom

Cooperation
- Health
- Food, agriculture and fisheries, and biotechnology
- Information and Communication Technologies
- Nanosciences, Nanotechnologies, Materials and new Production
- Technologies
- Energy
- Environment (including Climate Change)
    - Activity 6.2 Sustainable management of resources
        - Sub-Activity 6.2.1 Conservation and sustainable management of natural and man-made resources and biodiversity
            - **Area 6.2.1.4 Biodiversity**
- Transport (including Aeronautics)
- Socioeconomic Sciences and the Humanities
- Space
- Security

Table 1: Location of biodiversity related activities within the themes of the FP7 work program (http://ec.europa.eu/research/participants/portal/desktop/en/funding/reference docs.html#fp7).

The FP7 program ran from 2007 to 2013 and in 2012 biodiversity disappeared entirely from the titles. *Activity 6.2* changed towards *Challenge 6.2. Sustainable use and management of land and seas*, and in here biodiversity disappeared as a specific subtopic. Onwards to 2013, the topics inside the environment theme were further rearranged under different headings for the transition towards the Horizon 2020 program, and the biodiversity topic did not reemerge in the rearrangement. To bridge the FP7 program towards Horizon 2020, the focus of the FP7 program in 2012 shifted towards a stronger focus on innovation measures in support of market-uptake of products and services and to a stronger emphasis on participation of small and medium enterprises. The environment was henceforth framed within this new focus and was therefore made part of a theme concerned with resource efficiency. In Horizon 2020, biodiversity issues are touched upon in the call *Growing a Low Carbon, Resource Efficient Economy with a Sustainable Supply of Raw Materials*, but a specific focus on biodiversity did not reemerge.

3.2. Word use in the FP7 and Horizon 2020 calls

The total number of referrals to values or uses of biodiversity decreased by a quarter between 2007 and 2014 (Fig. 1b) and simultaneously the expression of biodiversity's values changed significantly in the documents. Within this time frame, 'ecosystem services' increased 1.5 times in use as an expression of the use or values of biodiversity, while goals related to 'sustainability' and 'conservation' decreased to half of their original word use (Fig. 1a; Table S1). In the early years of FP7, 'sustainability' values, 'conservation' values and 'ecosystem services' were the three main arguments for acting for biodiversity in the texts. By the end of FP7 in 2012-'13 and at the start of Horizon 2020 in 2014, 'ecosystem services' had become the foremost expression of the value of biodiversity mentioned, while values of 'conservation' and 'sustainability' have dropped significantly in comparison to 'ecosystem services'. There is a significant difference in change of word use between the referrals to 'ecosystem services' and referrals to other values through the years (Table S1; Fig. S1).

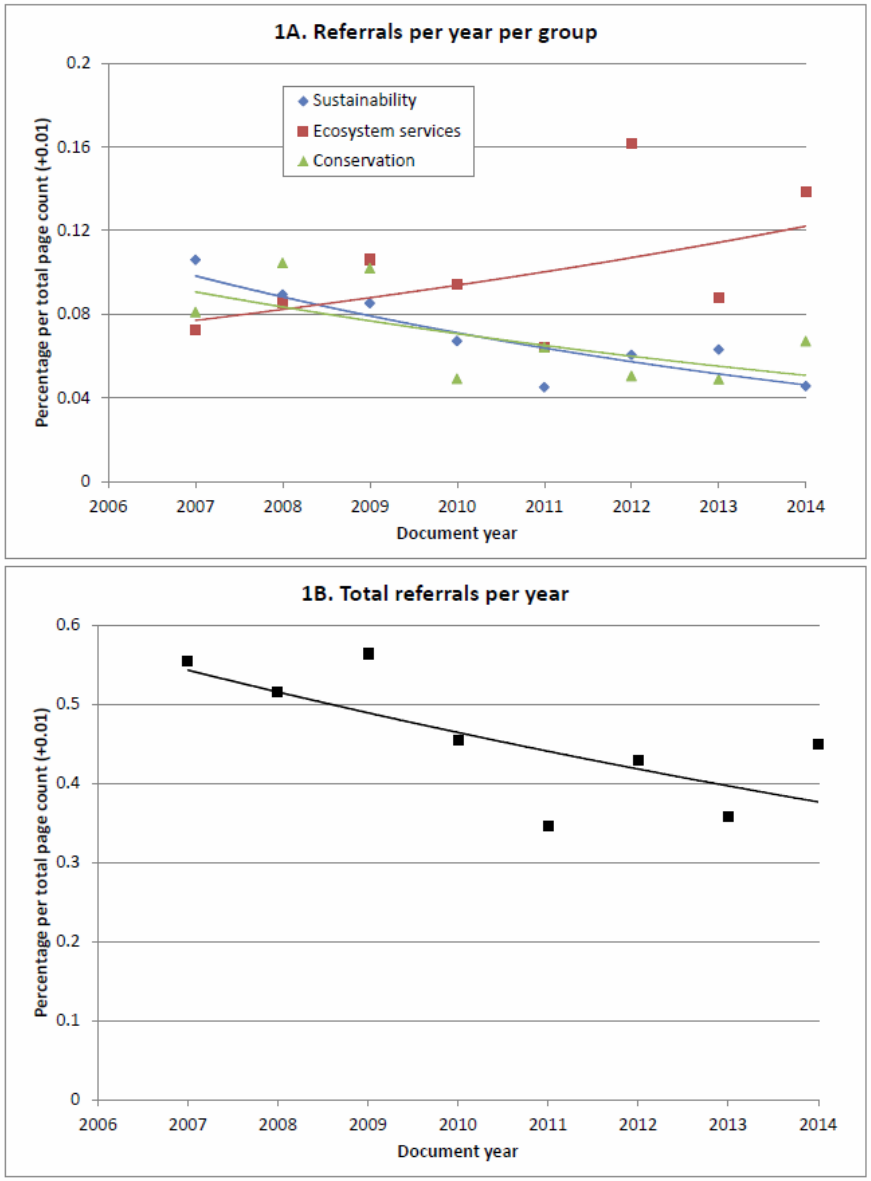
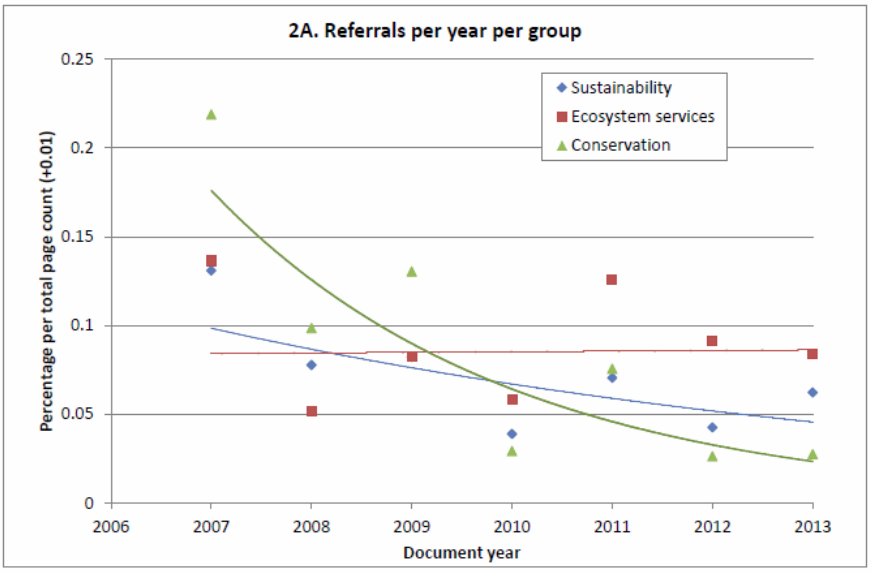


Figure 1. Word use analysis on FP7 Environment (Including Climate Change) and Horizon 2020 Climate action, environment, resource efficiency and raw materials. A = the percentage of words referring to values for each year, as a percentage of the total word count of the documents. Only sustainability, ecosystem services and conservation are taken up in this figure. For all 11 traced values and themes, see Fig. S1. B = the total referrals for each year, as a percentage of the total word count of the documents.

Sustainability values have a strong presence in the text, even when declining through the years. Values of equity and democratic decision making can be seen in either direct referrals or in referrals to stakeholder participation, but have a low presence in the text. Intrinsic values of biodiversity and associated ethical considerations are mentioned only three times in calls that specifically search for non-economic values and are therefore marginal in the text. The explicit mention of costs and benefits of biodiversity remains low in the documents. FP7 2012 introduces the word natural capital alongside ecosystem services as another expression of the economic value of biodiversity.

3.3. Word use in the FP7 project objectives

The projects accepted under FP7 research calls show first of all a trend of disappearance of biodiversity related subjects; i.e. a nearly three-quarters loss of biodiversity referrals between 2007 and 2013 (Fig. 2b). In the projects that still refer to biodiversity, the same trend is visible as observed in the call descriptions of the work programs, in that 'ecosystem services' emerges as the dominant expression of use or value and other goals referring to sustainability or conservation decreased in importance (Fig. 2a; Fig. S2). Referrals to 'costs and benefits' remained stable too. There is a significant difference in change of word use between the referrals to 'ecosystem services' and referrals to other values through the years in the project objectives (Table S2).



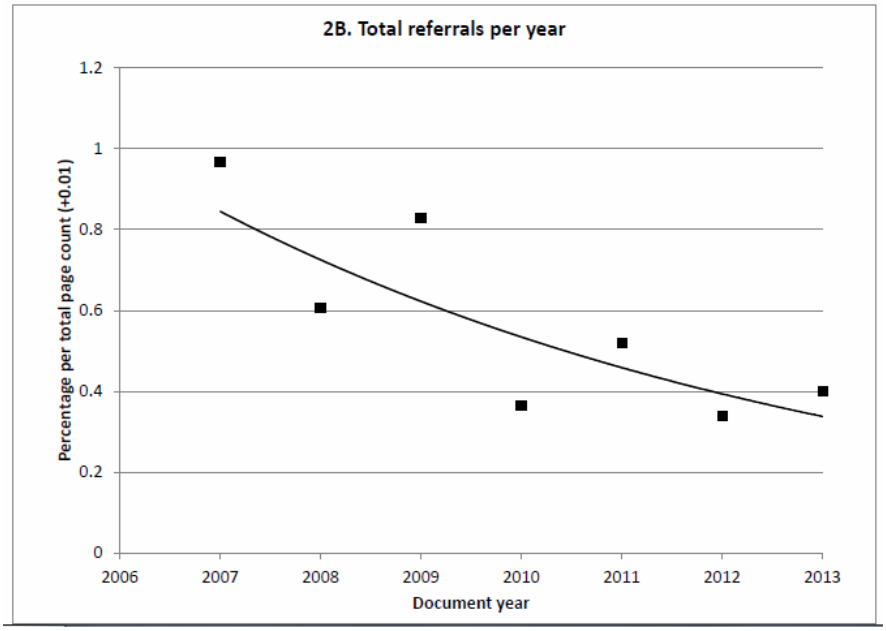


Figure 2. Word use analysis on the descriptions of the objectives of projects that were accepted under the FP7 Environment (Including Climate Change) theme. A = the percentage of words referring to values for each year, as a percentage of the total word count of the documents. Only sustainability, ecosystem services and conservation are taken up in this figure. For all 11 traced values and themes, see Fig. S2. B = the total referrals for each year, as a percentage of the total word count of the documents.

4. Discussion

4.1. Discussion of results

A clear shift in word use is visible in the environment themes of the FP7 and Horizon 2020 work programs towards using 'ecosystem services' as the foremost way to express the value of biodiversity. There is little explicit referral to economic valuation of biodiversity in the FP7 and Horizon 2020 documents, but determining ecosystem services is a strong precursor to economic valuation as it exists within the same frame of value expression (McCauley 2006; Gómez-Baggethun & Ruiz-Pérez 2011). Coupled with a simultaneous decrease of other expressions of values and goals such as 'conservation' and 'sustainability', 'ecosystem services' substitutes other expressions of value in the work programs. Because biodiversity research is funded on a competitive basis through FP7 and Horizon 2020, 'ecosystem services' is being put forth as the main motivating factor for future scientific research.

There are limitations to the methods used and the scope of this study. In our study of the call descriptions of the environment themes of the FP7 and Horizon 2020 documents, no conclusions can be drawn about the setup of the research projects accepted under these frameworks, or the thematic emphasis during their run and their practical research outcomes regarding biodiversity conservation. The word clouds we used can therefore only be used as an indicator of shifts in word use in the documents of the EU framework programmes. Nevertheless, the word frequency analysis allows us to infer changes in the importance of topics over time (Stemler, 2001). The shifts in word use observed in this study indicate a thematic shift over time in the underlying concepts related to biodiversity conservation in the environment themes of the FP7 and Horizon 2020 documents.

The EU research work programmes investigated here constitute only a part of subsidized research on biodiversity in Europe, being an addition to other networks such as BiodivERsA, COST and the European Science Foundation (ESF) and national efforts to subsidize a great number of research projects (BISE 2011; BiodivERsA 2013). The accepted projects investigated in this study, however, follow the same shift in their stated objectives as is observed in the open call descriptions. This suggests a trickle-down effect in which the shift towards 'ecosystem services' values in the work programs may lead to scientists adapting their language to that of the open call descriptions. This practice of highlighting keywords and contexts in adapting the research project objections to the call descriptions may not necessarily impact the conservation success of the accepted projects, but the value framework set down in open call descriptions may thus lead to a narrowing of expressions of value in scientific research and may lead to a greater focus on ecosystem services in the projects. The databases of BISE (2011) and BiodivERsA (2013)

indicate that research projects still cover a richness in themes, but the question to ask is whether ecosystem services is a good substitute for notions of biodiversity conservation in open call descriptions.

4.2. Implications and recommendations

A complex relationship exists between the clouds of ideas that make up biodiversity and ecosystem services. As explained by Mace et al. (2012), ecosystem services management may not always mean biodiversity conservation per se, and the expectation that managing ecosystem services will automatically enhance biodiversity is unfounded (Ridder 2008). Spatially, priority areas for biodiversity conservation and for ecosystem services generation may only weakly overlap and conservation success becomes dependent on trade-offs between ecosystem services (Chan et al. 2006). If the focus of conservation changes towards the maintenance of ecosystem services as end products, biodiversity's role as a regulator of ecosystem processes may be neglected in environmental policy (Isbell et al. 2015). Instead, biodiversity's role as underpinning the stability or quality of ecosystems and the flow of services should be at the center of describing its value.

The field conservation biology itself is divided on the issue of whether applications of the ecosystem services concept will lead to greater conservation success or not (Schröter et al. 2014). The argument of protecting nature for nature's sake only works for the converted, and we need the idea of ecosystem services to get more people involved in efforts of conservation. Ecosystem services might work in this regard because it uses the language of connection, emphasizing how biodiversity is part of people's lives (Armsworth et al. 2007). Conservation judgements are after all value judgements (Mace et al. 2012), and conservation priorities may be taken up quicker when they are reframed within relevant political contexts (Rose 2014).

But the language of ecosystem services has severe limitations in describing these connections, and is most suited to talk about biophysical goods and services such as food or water purification. It may only get people involved with nature in a limited way. To use ecosystem services to make people concerned about biodiversity loss therefore may not lead to successful biodiversity conservation but to a focus on the production of quantifiable services. There is a danger that nonmaterial values of biodiversity that describe the deeper connections between individuals and nature, such as identity values, spirituality, artistic and intergenerational values, are glanced over in ecosystem assessments unless special attention is paid to them. Nonmaterial values are difficult to elicit and take up in assessments, and frequently overlooked (Gould et al. 2014). The easier-to-express biophysical ecosystem services then sooner become the language of connection between society and nature, and they can be expressed in monetary terms as a decision support strategy for policy makers. But this introduces further complications for biodiversity conservation (Adams 2015), as the monetary valuation of biodiversity is currently inconsistent and incomprehensive about the values and functions of biodiversity (Bartkowski et al. 2015).

If one goal of conservation biology is to speak the language of connection to harness human values for successful biodiversity conservation, then ecosystem services addresses only a part of those values, and

a focus on them confronts us with their limitations. There are efforts to embed ecosystem services language in broader frameworks, where it becomes useful at particular steps in a decision making process. Laurila-Pant et al. (2015) suggests to use the language of ecosystem services for local decision analysis, and use biodiversity science to keep ecosystems stable for the services. Newer frames of valuing biodiversity are yet emerging in scientific literature focusing on socio-ecological resilience to solve problematic aspects of the ecosystem services framework (Norgaard 2010; Mace 2014). Alternative ways to express the value of biodiversity also exist. As Butler and Acott (2007) and Van der Born (2008) show, a majority of people already regard nature not from the perspective of a user, but as a tender or partner of nature on the planet.

The critiques mentioned above are not addressed in the environment themes of the FP7 and Horizon 2020 documents. The results show a decline of sustainability values, a lack of recognition of intrinsic values of biodiversity and of equity values in biodiversity management. Moreover, the general trends of European policy language in research away from biodiversity conservation as observed in this study are in stark contrast to recent publications on the state of biodiversity in Europe. Both the decrease of biodiversity-related projects and the marginal appearance of biodiversity loss as a recognized topic in the work programs is surprising in light of the struggle to reach the UN CBD Aichi biodiversity targets (Tittensor et al. 2014). Both the recent mid-term review of the EU biodiversity strategy to 2020 (EC, 2015) and the European Environmental Agency report on the State of Nature in the EU (EEA, 2015) show that no significant progress has been made towards the target to halt biodiversity loss in Europe by 2020. Also, the Eurobarometer survey on public attitudes towards biodiversity conservation (EU, 2015) shows that biodiversity loss is considered a very serious topic by eight out of ten Europeans.

The EEA report on the State of Nature in the EU (EEA, 2015) mentions measureable targets to fulfill the EU nature directives, but the language shift in FP7 and Horizon 2020 documents towards ecosystem services instead obscures concrete, measureable goals for conservation. The same need for concrete targets is apparent in the implementation of the European network of protected areas Natura 2000, in which a need is recognized by scientists for more basic research on species inventories and habitats (Kati et al. 2015). An obscuration of conservation goals is also observed in the BiodivERsA database from 2004 to 2011, in that the projects do not directly relate to targets to halt biodiversity loss (Gambette et al. 2014). For successful biodiversity conservation, we recommend that European research policy documents refrain from a total shift to ecosystem services and retain biodiversity conservation *an sich* as a policy goal via updated frames of biodiversity value. We think that the shift away from projects that refer to biodiversity conservation is of great concern.

Acknowledgments

The methods and appendices reported in the paper and are available in the Supplementary Materials. This research was supported by FP7 Grant Agreement 282625, BIOMOT: MOTivational strength of ecosystem services and alternative ways to express the value of Biodiversity.

References

1. Adams, W.M., (2014). The value of valuing nature. Nature, 346, 549-551.
2. Armsworth, P.R., Chan, K.M.A., Daily, G.C., Ehrlich, P.R., Kremen, C., Ricketts, T.H., Sanjayan, M.A. (2007). Ecosystem-Service Science and the Way Forward for Conservation. Conservation Biology, 21, 1383–1384.
3. Bartkowski, B., Lienhoop, N., & Hansjürgens, B. (2015). Capturing the complexity of biodiversity: A critical review of economic valuation studies of biological diversity. Ecological Economics, 113, 1–14.
4. BiodivERsA (2013). BiodivERsA database. Belgian Biodiversity Platform (v20131211) Accessed at http://www.biodiversa.org/database
5. BISE, 2011. Biodiversity Data Center. Available at http://www.eea.europa.eu/data-and-maps/data/eu-research-projects-on-biodiversity/projects/research/view/ (accessed October 2015).
6. Boitani, L., & Sutherland, W.J. (2015). Conservation in Europe as a model for emerging conservation issues Globally. Conservation Biology DOI: 10.1111/cobi.12530.
7. Butler, W.F., Acott, T.G. (2007). An Inquiry Concerning the Acceptance of Intrinsic Value Theories of Nature. Environmental Values, 16**,** 149–168.
8. Chan, K.M.A., Shaw, M.R., Cameron, D.R., Underwood, E.C., & Daily, G.C. (2006). Conservation Planning for Ecosystem Services. PLoS Biology, 4(11), e379. doi:10.1371/journal.pbio.0040379
9. Costanza, R., et al. (1997). The value of the world's ecosystem services and natural capital. Nature, 387, 253–260.
10. De Groot, R.S., Wilson, M.A., Boumans, R.M.J. (2002). A typology for the classification, description and valuation of ecosystem functions, goods and services. Ecological Economics, 41, 393–408.
11. EC. (2015). Mid-term review of the EU biodiversity strategy to 2020. Report from the Commission to the European Parliament and the Council. Available from:
12. http://ec.europa.eu/environment/nature/biodiversity/comm2006/pdf/mid_term_review_summary.pdf (accessed November 2015).
13. EEA. (2015). State of nature in the EU; Results from reporting under the nature directives 2007–2012. EEA (European Environment Agency). Available from: http://www.eea.europa.eu/publications/state-of-nature-in-the-eu (accessed June 2015).
14. EP resolution. (2014). Our life insurance, our natural capital: an EU biodiversity strategy to 2020. Available from: http://ec.europa.eu/environment/nature/biodiversity/comm2006/pdf/EP_resolution_april2012.pdf (accessed June 2015).
15. EU. (2015). Special Eurobarometer 436 “Attitudes of Europeans towards biodiversity”. DOI: 10.2779/832333.
16. Gambette, P., Eggermont, H., & Le Roux, X. (2014). Temporal and geographical trends in the type of biodiversity research funded on a competitive basis in European countries. BiodivERsA,

Fondation pour la Recherche sur la Biodiversité, Paris France. Available from: http://www.biodiversa.org/8 (accessed June 2015).
17. Gomez-Baggethun, E., Ruiz-Perez, M. (2011). Economic valuation and the commodification of ecosystem services. Progress in Physical Geography, 35, 613-628.
18. Gould, R.K., Klain, S.C., Ardoin, N.M., Satterfield, T., Woodside, U., Hannahs, N., Daily, G.C., & Chan, K.M. (2014). A Protocol for eliciting nonmaterial values through a cultural ecosystem services frame. Conservation Biology, 29, 575–586.
19. Hodge, I., Hauck, J., & Bonn, A. (2015). The alignment of agricultural and nature conservation policies in the European Union. Conservation Biology, DOI: 10.1111/cobi.12531.
20. Isbell, F., Tilman, D., Polasky, S., & Loreau, M. (2015). The biodiversity-dependent ecosystem service debt. Ecology Letters, 18, 119–134.
21. Kati, V., Hovardas, T., Dieterich, M., Ibisch, P.L., Mihok, B., & Selva, N. (2015). The challenge of implementing the European network of protected areas Natura 2000. Conservation Biology, 29, 260-270.
22. Laurila-Pant, M., Lehikoinen, A., Uusitalo, L., & Venesjärvi, R. (2015). How to value biodiversity in environmental management? Ecological Indicators, 55, 1–11.
23. Losey, J.E. & Vaughan, M. (2006). The economic value of ecological services provided by insects. Bioscience, 56, 311–323.
24. Mace, G.M. (2014). Whose conservation? Science, 345, 1558.
25. Mace, G.M., Norris, K., & Fitter, A.H. (2012). Biodiversity and ecosystem services: a multilayered relationship. Trends in Ecology and Evolution, 27, 19-26.
26. Matei, S., Henckel, L., Gauthier, C.A., & Le Roux, X. (2011). Biodiversity within the "Environment" theme of the 7th Framework Programme (2007-2010): funding amounts, success rates, temporal trends & comparisons between countries. BiodivERsA, Fondation pour la Recherche sur la Biodiversité, Paris France. Available from: http://www.biodiversa.org/359 (accessed June 2015).
27. McCauley, D.J. (2006). Selling out on nature. Nature, 443, 27-28.
28. Norgaard, R.B. (2010). Ecosystem services: From eye-opening metaphor to complexity blinder. Ecological Economics, 69, 1219–1227.
29. Nunes, P.A.L.D., & Van den Bergh, J.C.J.M. (2001). Economic valuation of biodiversity: sense or nonsense? Ecological Economics, 39, 203–222.
30. Pearce, D. (2007). Do we really care about Biodiversity? Environmental and Resource Economics, 37, 313–333.
31. Perrings, C., et al. (2010). Ecosystem Services for 2020. Science, 330, 323-324.
32. Pimentel, D., Wilen, C., McCullum, C., Huang, R., Dwen, P., Flack, J., Tran, Q., Saltman, T., & Cliff, B. (1997). Economic and environmental benefits of biodiversity. Bioscience 47**,** 747–757.
33. Ridder, B. (2008). Questioning the ecosystem services argument for biodiversity conservation. Biodiversity and Conservation, 17, 781–790.
34. Rose, D.C. (2014). The case for policy-relevant conservation science. Conservation Biology, 29, 748–754.
35. Schröter, M., Van der Zanden, E.H., Van Oudenhoven, A.P.E., Remme, R.P., Serna-Chavez, H.M., De Groot, R.S., & Opdam, P. (2014). Ecosystem Services as a Contested Concept: A Synthesis of Critique and Counter-Arguments. Conservation Letters, 7, 514–523.

36. Stemler, S. (2001). An overview of content analysis. Practical Assessment, Research & Evaluation, 7(17). Available from: http://PAREonline.net/getvn.asp?v=7&n=17 (accessed November 2015).
37. TEEB, The Economics of Ecosystems and Biodiversity: Mainstreaming the Economics of Nature: A Synthesis of the Approach, Conclusions and Recommendations of TEEB. (2010). Available from: http://www.unep.org/pdf/LinkClick.pdf (accessed June 2015).
38. Tittensor, D.P., et al. (2014). A mid-term analysis of progress toward international biodiversity targets. Science, 346, 6206.
39. Van den Born, R.J.G. (2008). Rethinking Nature: Visions of nature of a Dutch public. Environmental Values, 17, 83-109.
40. Wood, P. (1997). Biodiversity as the Source of Biological Resources: A New Look at Biodiversity Values. Environmental Values, 6, 251-68.

Appendix A. Supplementary data

Methods:

The FP7 and Horizon 2020 framework programmes comprise an inner universe of official documents, but the focus in this study is on the documents published as the environment theme work programs that list the open research calls, which are the key documents for scientists who want to apply for research subsidies and are the most direct communication among the documents from the European policy sphere to scientists working in Europe. The following documents we consider to be outside the scope of this paper: original proposals for the programs and impact assessment reports that detail the expected impacts of the programs on the world. Also outside the scope are a number of documents on their legal basis and their grant and funding mechanisms, including proposals for public-private and public-public partnerships and manuals on proposal submissions.

The method used here is an analysis of the FP7 and Horizon 2020 environment theme work programs at two levels: the structure of the work program in chapters and subchapters, and a coding of terms that are to be searched for in the documents. In the writing of the open calls of work programs of Horizon 2020 and FP7 there are necessarily constraints in word use and word number. Out of necessity, the calls need to be short and clear in communication yet leaving enough room in interpretation for multiple possible projects to be send in, and using vocabulary from the respective fields of research they are addressing. Such documents offer no room for nuanced discussions of meaning in the call descriptions. However, the specific words used in the documents are reflections of a state of discussion within a field of research, and as such carry assumptions with them and expectations of proposals that answer the call.

A word use analysis was performed on the documents of the FP7 '*Environment (including climate change)'* theme from 2007 to 2013 and its follow-up theme '*Climate action. environment. resource efficiency and raw materials'* from Horizon 2020*.* Even though other themes in the framework documents may touch on biodiversity, the analysis focused only on this theme, because the focus of the study is on biodiversity wording for conservation purposes. Only '*Environment (including climate change)'* and its follow-up theme in Horizon 2020 address the environment as a concern on its own and is therefore the theme in which multiple values of biodiversity for conservation can be most readily expressed. In contrast, other themes that touch on biodiversity in the call descriptions, such as '*Food, agriculture and fisheries, and biotechnology',* focus on sustainable use and stimulation of production systems in which biodiversity is seen as playing a role in production processes, for example as genetic stock or industrial micro-organisms. We chose therefore to exclude these from the textual analysis to get trends of biodiversity wording for conservation purposes into sharper focus. All FP7 and Horizon 2020 documents were retrieved from http://ec.europa.eu/research/index.cfm.

In the word use analysis a coding of terms is applied to two aspects of the value of biodiversity: (1) what is being referred to at instances in the documents when biodiversity or a related term is mentioned and (2) what value is attached to it. For example, the documents might refer to either nature, ecosystems or biodiversity, with each term overlapping in meaning. We take all terms as direct or indirect referrals to

biodiversity. The following terms comprise our search list of referrals to biodiversity: biological/ecological resource(s), ecosystem(s), bio-/biological diversity, nature, biological/ecological diversity, genetic resource(s) and green infrastructure. For each instance when a referral is made to one of these terms, the context of the paragraph clarifies which values are attached to this term. For example, ecosystems can be mentioned in the context of economic productivity, sustainable growth, food security, certain classes of ecosystem services for the economy or society or other values. After locating the relevant paragraphs in the documents via an initial automatic search for referrals to biodiversity, the paragraphs are read and analyzed for these values manually. Thus, a list is built up of all the values of biodiversity that are recognized in the text as relevant (Table S3). Only paragraphs in which biodiversity is referred to are taken up in this analysis. The frequency with which the values are mentioned in the paragraphs where biodiversity is referred to is taken as an indicator of the weight that is given to these values.

The list of mentioned values is summarized into groups: ecosystem services, sustainability values, socio-economic values, conservation value, etc. (Table S3). Some groups, such as climate change mitigation and livelihood values, could be counted as ecosystem services but are mentioned separately to enrich the data. In addition, we kept track of referrals to stakeholder participation and cost benefit analyses. These are not necessarily values of biodiversity but give us further information about how biodiversity values are expected to be expressed in the projects. The resulting eleven groups of values were tracked through the years in the documents and trends become visible (Figure S1).

The same word use analysis using the same stepwise plan is done on descriptions of the objectives of accepted projects under the FP7 '*Environment (including climate change)'* theme from 2007 to 2013. The analysis of descriptions of projects is done primarily to investigate whether any trends we find in the open call descriptions of the work programmes are mirrored in the stated objectives of projects that are submitted to these open calls. For the descriptions, we took the text mentioned as the objective of a project on the project page on http://cordis.europa.eu/home_en.html.

For testing the difference in trend between the use of the words referring to 'ecosystem services' and those of the other groups, we made a dataset of the word count per group per year. This dataset was analyzed by applying a linear model that assumes that the word count per group per year is depending on year, group and the interaction between year and group. The interaction terms of this model give the coefficients of the regression of word count by year per group. The differences of these regression coefficients between that of 'ecosystem services' and the other groups show how the trends differ. These can be tested on being significantly different from zero – no difference in trend between 'ecosystem services' and the one tested – by testing the difference between the interaction terms of the model and zero, because the interaction terms of the model are actually contrasts between the regression coefficient of 'ecosystem services' and the other regression coefficients. This statistical analysis was performed using the program R-3.0.2, using a linear model, after log transformation of the word counts as percentage for optimal distribution of residuals values: lm(ln(percentage+0.01)~year*group). For the results we consider p-values below 0.1 as a significant difference.

Figures:

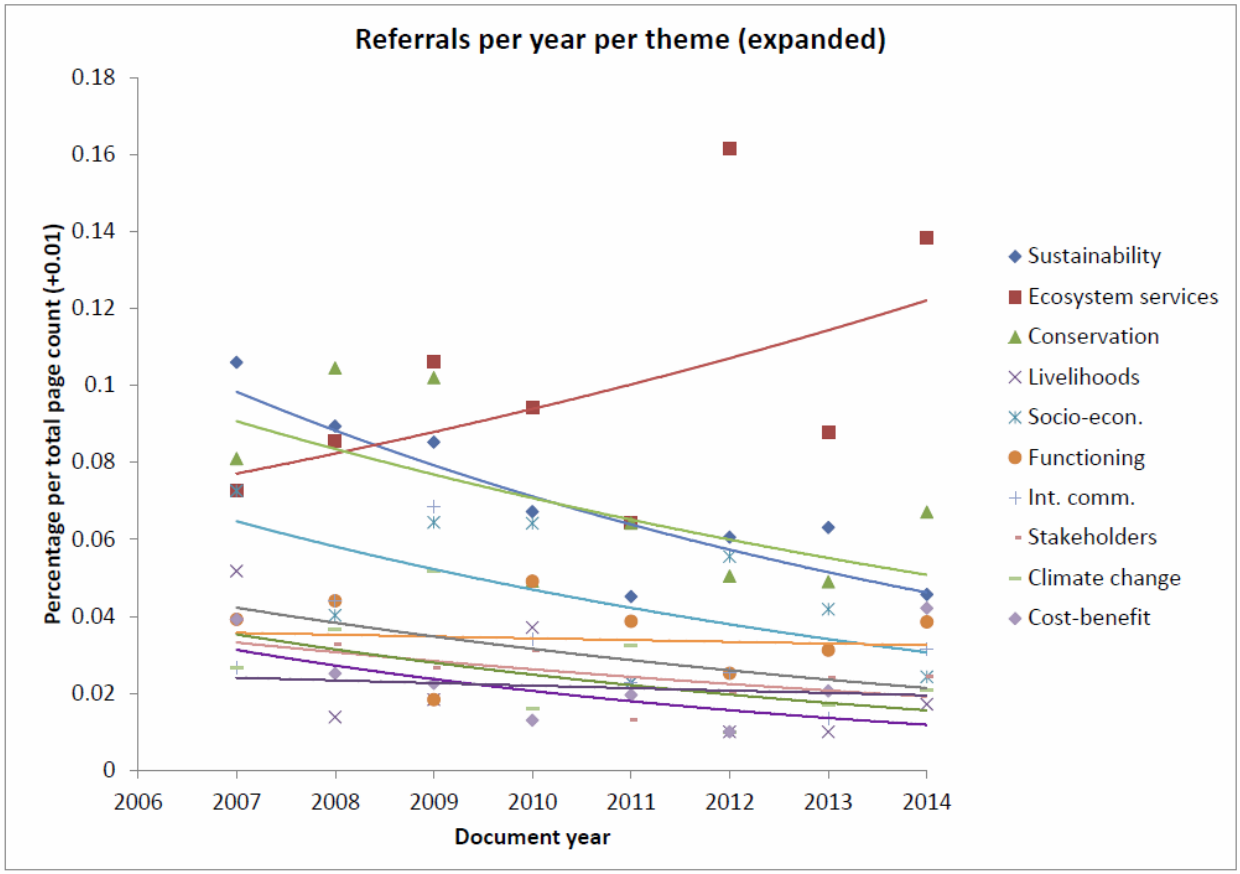


Figure S1: Word use analysis on FP7 Environment (Including Climate Change) and Horizon 2020 Climate action, environment, resource efficiency and raw materials. Shown is the percentage of words referring to values for each year, as a percentage of the total word count of the documents. The trend lines represent the predicted values of our statistical model.

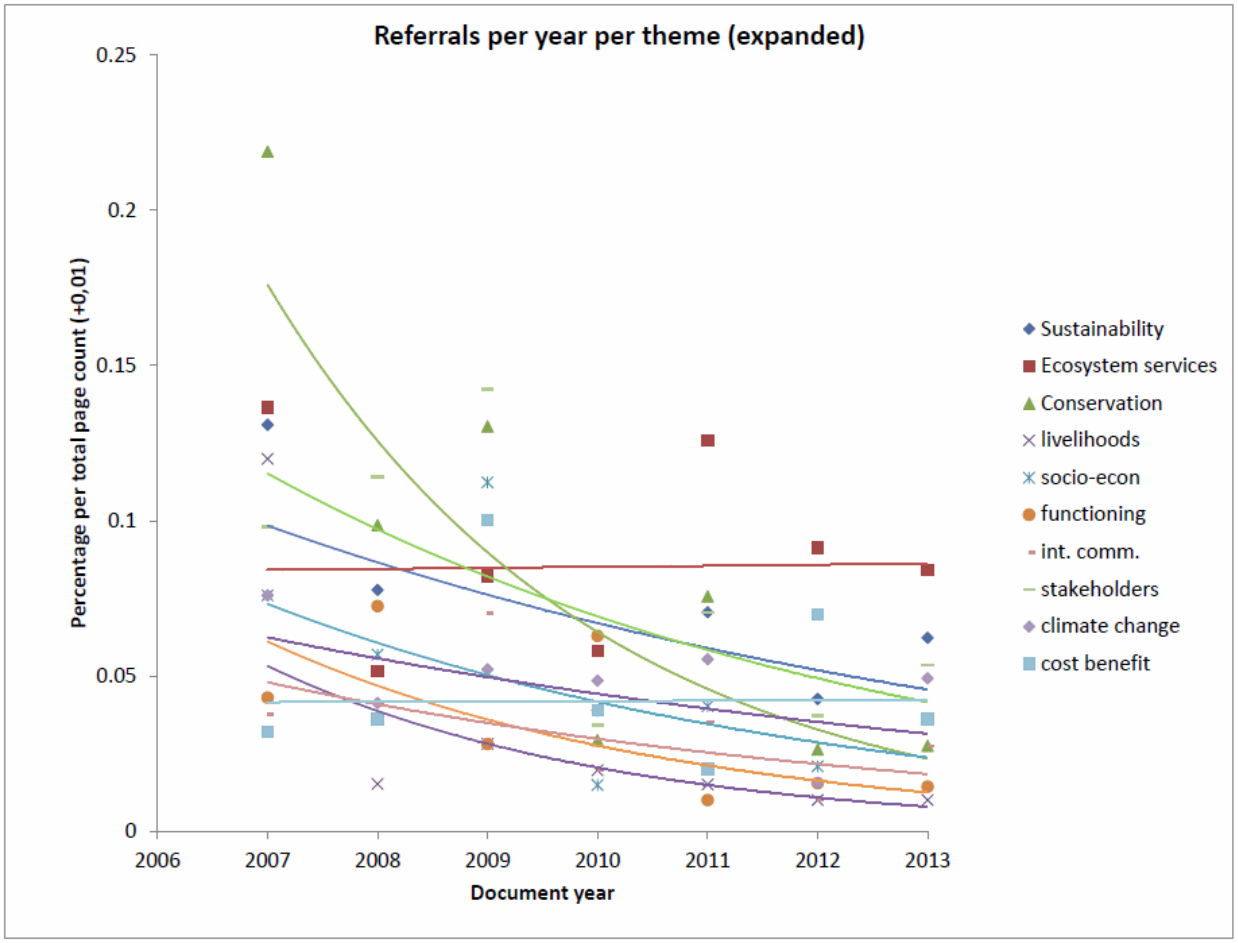


Figure S2: Word use analysis on the descriptions of the objectives of projects that were accepted under the FP7 Environment (Including Climate Change) theme. Shown is the percentage of words referring to values for each year, as a percentage of the total word count of the documents. The trend lines represent the predicted values of our statistical model.

Tables:

Table S1: Estimated contrasts between the regression coefficient of the group 'ecosystem services' by year and other groups in the work programs of FP7 and Horizon 2020. Based on the interaction terms of the linear model lm(ln(percentage+0.01)~year*group). For the results we consider p-values below 0.1 as a significant difference. Signif. codes: '*'p <0.05, '.' p<0.1.

Table S1: Estimated contrasts between groups in FP7 and Horizon 2020					
Value of biodiversity	Estimate	Std. Error	t value	Pr(>|t|)	Significance
Sustainability	-0.17362	0.08521	-2.038	0.0456	*
Conservation	-0.14855	0.08521	-1.743	0.0859	.
Livelihood	-0.20440	0.08521	-2.399	0.0193	*
Socio-economic	-0.15737	0.08521	-1.847	0.0693	.

Functioning/production	-0.07922	0.08521	-0.930	0.3540	
Competition	-0.13422	0.08521	-1.575	0.1200	
International commitments	-0.16297	0.08521	-1.913	0.0601	.
Stakeholder participation	-0.14408	0.08521	-1.691	0.0956	.
Climate change mitigation	-0.18245	0.08521	-2.141	0.0360	*
Costs and benefits	-0.09575	0.08521	-1.124	0.2652	

Table S2: Estimated contrasts between the regression coefficient of the group 'ecosystem services' by year and other groups in the descriptions of the objectives of projects accepted under FP7 '*Environment (including climate change)'*. Based on the interaction terms of the linear model lm(ln(percentage+0.01)~year*group). For the results we consider p-values below 0.1 as a significant difference. Signif. codes: '*'p <0.05, '.' p<0.1.

Table S2: Estimated contrasts between groups in project objectives					
Value of biodiversity	Estimate	Std. Error	t value	Pr(>|t|)	Significance
Sustainability	-0,132187	0.137462	-0,962	0.3409	
Conservation	-0,340472	0.137462	-2,477	0.0167	*
Livelihood	-0,322341	0.137462	-2,345	0.0230	*
Socio-economic	-0,191958	0.137462	-1,396	0.1688	
Functioning/production	-0,268850	0.137462	-1,956	0.0561	.
International commitments	-0,163342	0.137462	-1,188	0.2403	
Stakeholder participation	-0,174070	0.137462	-1,266	0.2113	
Climate change mitigation	-0,118666	0.137462	-0,863	0.3921	
Costs and benefit	-0,001333	0.137462	-0,010	0.9923	

Table S3: Values of biodiversity found in the work programs, summarized in groups	
Ecosystem services:	Sustainability:
Ecosystem services	Sustainable management
Ecosystem's services	Sustainability
Environmental services	Sustainable way
Goods and services	Sustainable development
Products and services	Sustainable use
Service provision	Ecologically sustainable
Service delivery	Sustainable utilization
Natural capital	Sustainable policy actions
Human health	Sustainable pathways
Quality of life and health	Sustainable economic activities
Coping with noise	Sustainable processes
Health and wellbeing	Sustainable exploitation
Energy efficiency	Sustainable societies
Ecosystem water use	Green economy

Flood protection
Environmental goods and services
Biotechnological potential
Biotechnological applications
Industrial use
Capacity to deliver services
Multipurpose green infrastructure
Public goods
Range of services
Wood production
Water quality
Combat desertification
Value of pollination
Assimilative capacity of ecosystems
Natural products
Tourism
Coastline protection
Groundwater renewal
Recreation
Payments for ecosystem services

Socio-economic:

Social and economic impacts
Costs and social consequences
Social economic and other values
Species of socio-economic importance
Species of community interest
Species of policy relevance
Socioeconomic valuation
Economic risks
Economic impacts
Quantify economic and ecological values
Economic objectives
Economic dimensions
Multiple use
Economic valuation of impacts
Economic valuation
Greening the economy
Ecological and economic resources
Socioeconomic aspects/dimensions/context
Socioeconomic implications
Minimizing risks for society
Mitigating risks
Economic and social wellbeing
Quantify economic value

Sustainability goals
Offsets
No net loss

Conservation:

Ecosystem conservation
Ecosystem protection
Ecosystem restoration
Ecosystem resilience
Ecosystem enhancement
Future protected areas
Ecosystem health
Protect and conserve
Stability and resilience
Ecosystem recovery
Reverse biodiversity loss
Tipping points
Ecosystem quality
Preservation
Thresholds
Regime shifts
Ecological connectivity
Fragmentation
Ecological value
Good environmental status
Vulnerability of ecosystems
Support the diversity of life
Adaptation and restoration
Viability of populations
Favorable conservation status
Essential habitats
Biological quality
Ecological quality
Rebuilding
Environmental damage

Functioning:

Potential of green infrastructure
Functions
Innovation potential
Functioning
Eco-innovation
Eco-efficiency
Functional

Economic sectors Market and nonmarket impacts Social and economic consequences Social and individual wellbeing Support economies. societies and individual wellbeing Economic and social assessment Valuation of biodiversity Socioeconomic criteria Human welfare Relevant economic activities Socio-cultural and economic contributions Economic. social and cultural development Societal impacts Involvement industrial sector Contribution to SMEs	Applications Functions and processes Ecosystem function Functional ecological networks Production Functional elements Productivity Functioning or productive capacity Significant ecological functions Functionalities Multi-functionality
Climate change: Regulating the climate system Adapting to climate change Carbon sink Mitigation of climate change Carbon uptake Response to climate change Carbon and greenhouse gas Carbon pools Carbon sequestration Adaptation to climate changes Carbon storage Terrestrial sinks Feedback on the climate system Resilience to climate change	International cooperation: International cooperation International efforts International biodiversity targets Building on the outcomes of the MEA Supports the recent Communication International commitments Strategy Strengthening work of EU scientific institutions UN Convention Implementation of Directive International obligations International agreements Natura 2000 Transferability between countries Knowledge transfer Promoting strategic partnerships Boosting international research International initiatives Contribution to Millennium Development Goals Scientific collaboration Participation for countries European cooperation Global network Integrated maritime policy International conventions Relevant EU legislation
Cost-benefit: Benefits Cost-effectiveness Extensive benefits Maximum benefit Deliver major benefits Costs and benefits Costs Quantification of the costs Use and nonuse values Societal benefit	Stakeholders: Participatory approaches Stakeholder perspective Interests of different stakeholders

Opportunities and risks Livelihoods: Human wellbeing Urban and rural development Contribute to food security Regional economies Impact at local and regional levels Environmental safety and welfare Livelihoods Equitable Rural and urban environments Interdependencies' Coupled human-environment system Equitable way Urban development Relationship urban area and surrounding landscape Human dependence on biodiversity Welfare dependent Vulnerability of livelihoods Husbanding Rural marginal areas Deal with conflict Conflict reconciliation	Awareness raising Public access to data Involve civil society Stakeholder concerns Relevant actors Relevant stakeholders Public at large Engagement with local communities Multi-stakeholder dialogues Participatory initiatives Engage citizens Citizen awareness Competitiveness: Economic competitiveness European competitiveness Commercially important Commercial interest