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Report on EU biodiversity research gaps and priorities and strategic foresight activities

Deliverable 2.3 (MS16)

WP2: The European biodiversity research landscape and science-policy integration
WP leader: Henrik Lange – The Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning (Formas)

Task 2.3: Analyse research agendas and identify knowledge gaps and research priorities
Task leader: Estelle Balian/Hilde Eggermont (BelSPO - Belgian Science Policy Office- Belgian Biodiversity Platform)

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Report on EU biodiversity research gaps and priorities and strategic foresight activities

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1 Introduction

WP2.3 is focusing on the analysis of European and international policies (biodiversity policies and research policies) to characterize a major piece of context for the research agenda of BiodivERsA partners (i.e. national funding agencies) within an international agenda.

In a first phase, we performed an analysis comparing and analyzing the key documents of International and European policy and strategies to identify current main research orientations and needs in the field of biodiversity and ecosystem services. In a second phase, we looked at the results of two leading events organised in 2013 to further explore research priorities in Europe: the European Platform for Biodiversity Research Strategy (EPBRS) workshop: "Investing in innovative research for nature and our livelihoods: strengthening the research strategy to reinforce the ERA on Biodiversity" organised in Brussels on April 11-12 2013, and the Alter-Net conference "Science underpinning The EU 2020 Biodiversity Strategy" organised in Ghent on April 15-18 2013. Finally, we report on the BiodivERsA strategic foresight workshop organised on June 11-12 2014 in Brussels: 'Nature-Based Solutions in a BiodivERsA context'.

These analyses and event outputs can be used to define and position the priorities of BiodivERsA partners and moreover their common priorities within the international and European contexts.

2 Analysis of current international and European research strategy frameworks and priorities for biodiversity

2.1 Methodology

2.1.1 Documents analysed

We collected available international and European key scientific strategies along with Environmental and Science policy frameworks:
- The DIVERSITAS Science Plan (2002) built around four core projects (bioGENESIS, bioDISCOVERY, bioSUSTAINABILITY and ecoSERVICES) as well as its cross-cutting networks.
- The EPBRS's European Biodiversity Research Strategy 2010-2020
- The CBD strategic plan 2011-2020 with its Aichi Targets
- The EC Communication on Biodiversity: our life insurance, our natural capital: an EU biodiversity strategy to 2020

In addition, we took into account the DIVERSITAS new vision 2012-2020 launched in 2012 at the "Planet under Pressure" conference on 26-29 March 2012: *Biodiversity and*

ecosystem services science for a sustainable planet (Larigauderie et al. 2012[1]), which has be taken into account by the new initiative Future Earth launched in June 2012 (http://www.icsu.org/future-earth). The main structure around DIVERSITAS core projects and crosscutting networks is remaining (See Annex I) but it is completed by key challenges.

This is not an exhaustive list of documents proposing visions and strategies for biodiversity research but we limited the analysis to these comprehensive frameworks at international and European level. Each strategy was broken down in its key statements, targets, actions and/or challenges. For each of these statements, we identified keywords and deducted a possible overarching label. Results of the allocation of labels are presented in Annexes IIa&b. We separated the overarching labels in two types:
- The ones referring to the content/research thematics
- The ones referring to principles for research structures, organisation and processes.
This led us to define 7 labels referring to research priorities *per se,* plus 7 labels corresponding to enabling actions for biodiversity research.

All thematics are of course linked to each other, but they represent a specific angle on the issues. It is always possible to reorganise the labels differently or to define more detailed labels. We allocated a maximum of two labels to one statement/priority in the documents reviewed in the present analysis.

2.1.2 Seven labels referring to main biodiversity research thematics

In the group related to research content, we identified five plus two additional main labels/thematics for Biodiversity Research (see Annex IIa&b):
- Ecosystem services in relation to biodiversity
- Understand responses to global change and adaptation to change
- Support to conservation and management of biodiversity
- Support to sustainable use of biodiversity (Agriculture, Fisheries and Forestry)
- Understand social, economic and policy drivers of biodiversity change

Two additional aspects were identified:
- the need to "Document biodiversity"
- the need for "Innovation and ecological engineering based on biodiversity"

The thematics "conservation and management" and "sustainable use" are tightly linked regarding the aspect of management but we separated them based on criteria related to the primary goal of management:
- if it is to conserve/restore biodiversity, or the management focuses on protection or response facing a specific threat (e.g. Invasive Alien Species or Pollution) then we allocated the label "Conservation and Management".

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[1] Larigauderie A, Prieur-Richard A-H, Mace GM, Lonsdale M, Mooney HA, Brussaard L, Cooper D, Cramer W, Daszak P, Diaz S, Duraiappah A, Elmqvist T, Faith DP, Jackson LE, Krug C, Leadley PW, Le Prestre P, Matsuda H, Palmer M, Perrings C, Pulleman M, Reyers B, Rosa EA, Scholes RJ, Spehn E, Turner II BL and Yahara T. 2012. Biodiversity and ecosystem services science for a sustainable planet: the DIVERSITAS vision for 2012-20. *Current Opinion in Environmental Sustainability* 4(1):101-105

-   if it is to promote a sustainable use of a resource (e.g. Fisheries, agrobiodiversity, or Forestry) , we allocated the label "Sustainable use".

Reference to past BiodivERsA calls is made at appropriate places, to indicate that they clearly address pressing issues.

2.1.3   Seven labels referring to main enabling actions for biodiversity research

The second group of labels referred to some key principles and enabling actions for biodiversity research:
-   Promotion of "Large infrastructures for biodiversity research"
-   The need to "Enhance interdisciplinary/transdisciplinarity"
-   Ways to enhance "Participatory approaches and engagement of stakeholders"
-   Knowledge management
-   Capacity building
-   Development of biodiversity science-policy interfaces
-   Funding.

Again, reference to BiodivERsA activities and products is made at appropriate places, to indicate that they relate to identied enabling actions.

2.2   Results

2.2.1   Thematics for biodiversity research

- **Ecosystem services in relation to biodiversity**

All the strategies and policy frameworks analysed recognise that the nature and strength of the links between ecosystem services and biodiversity are issues of paramount importance for biodiversity research: The Strategic Goal D of the CBD strategic plan focuses on the benefits from biodiversity and ecosystem services for human well-being. The EU Biodiversity strategy 2020 is emphasizing the question of restoring degraded ecosystem services and the concept of green infrastructure to maintain ecosystem services and preserve associated biodiversity. Similarly, DIVERSITAS and EPBRS have emphasized the need for research on defining and measuring ecosystem services, in particular levels of service delivery, as well as research on links between biodiversity and ecosystem functioning and services.
➔ *These aspects have been addressed as one of the two axes of the BiodivERsA call launched in November 2010.*

- **Understanding responses to global change and adaptation to change**

EPBRS and DIVERSITAS have highlighted the need for research on global change effects on biodiversity, tipping points and resilience as well as modelling and scenarios. Aspects related to climate change and its interactions with biodiversity are included in this theme, while research on capacity to adapt to global change is also given high priority. The CBD strategic plan and the EU biodiversity strategy, however, do not address directly the notion of adapting to change.

➔ *Topics related to scenarios, tipping points and resilience were at the heart of the BiodivERsA call launched in November 2011.*
➔ *Biodiversity responses to global change components are included in most of the BiodivERsA calls, while response to climate change was explicitly addressed in the call launched in 2008.*

- **Support to conservation and management of biodiversity**

Both EPBRS research strategy and DIVERSITAS science plan include recommendations directly related to support to biodiversity conservation and management. Two crosscutting networks of DIVERSITAS address specifically conservation and management of 'Freshwater biodiversity' and 'Mountain biodiversity'. There are also ambitious goals in both the CBD and the EU strategies to improve conservation and implement effective restoration. The Aichi targets emphasize in particular issues related to pollution, invasive species and vulnerable ecosystems. The EU Biodiversity Strategy also emphasizes the invasive alien species issue in its Target 5. Some principles for biodiversity research are also identified in both environmental strategies such as improving participatory planning, knowledge management and capacity building to improve conservation and management. Along these lines, DIVERSITAS focuses a core project on adaptive governance and management.
➔ *The topic of the BiodivERsA call launched in November 2012 was "Invasive species and biological invasions".*

- **Support to sustainable use of biodiversity (Agriculture, Fisheries and Forestry)**

DIVERSITAS crosscutting network 'AgroBiodiversity' focuses on the research agenda for biodiversity and sustainable agro-systems. Support to "Sustainable use" is also present in the EPBRS research strategies in the recommendation to better understand and develop guidance for management and preservation of ecosystem services. Similarly, both the CBD and the EU strategies have a strong focus on ways to ensure a sustainable use of diverse natural resources and ways to maintain and enhance biodiversity through a better management of these resources and their use.
➔ *The BiodivERsA call launched in November 2013 (jointly with the FACCE-JPI) focused on "Promoting synergies and reducing trade-offs between food supply, biodiversity and ecosystem services".*

- **Understand social, economic and policy drivers of biodiversity change**

Ultimately, underlying causes of biodiversity loss are related to our life style, value system, consumption and production systems etc. Going further than the proximal pressures experienced by biodiversity (habitat degradation, pollution, etc.) is now necessary and research should address social and economic processes, as well as governance systems, influencing the way we interact with our natural environment and generating current pressures on ecosystems and species. Along the same lines, EPBRS has emphasized the need to implement research that links biodiversity and other grand challenges such as water, food, human health, energy, etc., whereas DIVERSITAS new vision highlights the need to build transformative capacity and the consequences for the equitable access to ecosystem services by local and global human populations. Although it could be included in several other axes, in particular 'understanding responses to global change and adaptation to change', this thematic receives such a strong focus in

the CBD strategic plan and in the EU Biodiversity strategy that it is important to address it separately in terms of research needs.

- **The need to** "**Document biodiversity**"

The current international and European research strategies clearly highlight that the 5 priorities presented above could not be tackled properly without a "stronger knowledge basis developed by documenting and monitoring biodiversity" at all relevant levels (genes, species, ecosystems). This implies in particular to document ill-studied components such as soil or microbial biodiversity, and to study evolutionary processes underlying diversification or adaptation capacity. These are the scientific basis for all research thematics, identified as such in both the EPBRS strategy and the DIVERSITAS Strategic plan (i.e. DIVERSITAS core projects bioDISCOVERY & bioGENESIS).

- **The need for "Innovation and ecological engineering based on biodiversity"**

EPBRS strategy refers to research and innovation in terms of technological breakthrough inspired by Nature, and of social innovation (e.g. governance of the commons).

A main difference between the environmental policies (CBD and EU biodiversity strategies) and research strategies (EPBRS and DIVERSITAS) is related to the thematics of "Understanding responses to global change and adaption to change" and of "Documenting biodiversity" that are only present in the research strategies. It is clear however that conservation, management and sustainable use can only be tackled if we document biodiversity and its drivers of change.

Underlying causes of biodiversity loss are also more visible in the environmental policies and do not appear with the same priority in EPBRS research strategy and the previous DIVERSITAS science plan. However the revised DIVERSITAS strategic plan puts more emphasis on these underlying drivers.

2.2.2 Enabling actions for biodiversity research

The CBD action plan highlights the need to ensure that knowledge, science base and technologies related to biodiversity are improved, widely shared and transferred, and applied (Target 19). The EU biodiversity strategy does not mention principles for biodiversity research per se but refers to the need to improve monitoring (Action 4) and knowledge (Action 5) and to engage stakeholders (Action 3). Along these lines, the EPBRS research strategy and the DIVERSITAS new vision emphasize the need for interdisciplinary/transdisciplinary approaches and the importance of engaging all relevant stakeholders, including a specific mention of indigenous people in the DIVERSITAS new vision. Both also mention the need to improve the Science-Policy Interface for biodiversity and ecosystem services. In addition, DIVERSITAS and EPBRS strategies address the way information/data is generated and exchanged, indicating the importance to strengthen and further develop large research infrastructures and to ensure open access to data.

The EPBRS research strategy has a special emphasis on education and career, and on improving communication and the use of research results.

➔ *Since 2008, BiodivERsA selects research projects based on their academic excellence and their policy relevance and societal impacts. This includes the promotion of stakeholder*

engagement and dissemination of results. BiodivERsA recently published a Stakeholder Engagement Handbook, and several policy briefs based on funded projects results.

3   Further identification of biodiversity research priorities during devoted events in 2013

In addition, we then analysed the outputs of two main events organised in 2013 to identify priorities for research on biodiversity and ecosystem services: an EPBRS workshop which built explicitly on a preliminary analysis made by BiodivERsA (MS 15); and an Alter-Net conference organised to support the EU 2020 Biodiversity Strategy. We checked to what extent the priorities identified during these two events were consistent with the 7+7 priorities identified above, and whether additional main priorities needed to be included.

3.1   Outcomes of the EPBRS 2013 workshop: "Investing in Innovative Research for Nature and our livelihoods - Strengthening the research strategy to reinforce the ERA on Biodiversity"

The EPBRS workshop[2] built on the BiodivERsA analysis reported above. Here we present the top six areas identified by EPBRS and relate them to the results of the analysis of key documents presented above. We indicate in green which target(s) of the EU Biodiversity Strategy 2020 could particularly benefit from the identified research priorities, although all research priorities are relevant for all targets.

- **Area 1: Documenting and monitoring biodiversity**

This priority is very close to the 6th research priority identified above "Document biodiversity". More particularly, the sub-priorities identified during the EPBRS workshop were:

1. Development of innovative infrastructures to provide cost-effective, more unified, automated monitoring and archiving systems, including use of existing technologies, and citizen science

   o Particularly important for EU biodiversity strategy Target 4

2. Innovative methodologies for maintaining and providing access to data from biodiversity research taking into account intellectual property rights

3. Consistent (time and scale) indicators at national/ EU/international level for all levels of biodiversity (genes, species, ecosystems)

4. New monitoring designs to evaluate mitigation and adaptation policies and practices

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[2] Full report available at: http://www.epbrs.org/event/show/35

5. Methodologies for measuring and mapping ecosystem services

   o Particularly important for EU biodiversity strategy Target 2

- **Area 2 : Drivers of change and responses to impacts from anthropogenic pressures**

This priority is close to the 2nd research priority identified above "Understand responses to global change and adaptation to change". More particularly, the EPBRS report stressed that research in this area should cover the five drivers identified by the Millennium Ecosystem Assessment (overexploitation, land use change, invasive species, climate change and pollution). It should also cover emerging (or re-emerging) drivers such as new technologies (e.g. nanotechnology), bioenergy production, and impact of armed conflicts in certain regions of the world. Within this context the sub-priority areas were:

1. Quantify the interacting effects of *combinations* of drivers on biodiversity and ecosystem services (the cocktail effect)

   o Particularly important for EU biodiversity strategy Target 5

2. Assess the effectiveness of measures taken to conserve biodiversity and ensure sustainable use of ecosystem services and to develop new measures, including restoration and intervention measures

   o Particularly important for EU biodiversity strategy Targets 2, 4 and 5

3. Assess the impact of measures taken to adapt to or mitigate other environmental challenges (e.g. climate change) on biodiversity and ecosystem services, particularly the unintended consequences of such measures.

   o Particularly important for EU biodiversity strategy Target 4, specifically research on benthic trawling in particular the effects of selective gear and practices) on seafloor integrity and development of innovative new improved gear to reduce biodiversity loss

4. Understand the interactions between different organisational levels (from genes to ecosystems) and how drivers of change result in differential responses between and within these organisational levels to result in unexpected responses such as changes in community composition.

- **Area 3 : Capacity to forecast, identify evidence-based policy & management options and scenarios to adapt to change.**

This priority corresponds to key aspects of the 1rst research priority identified above "Ecosystem services in relation to biodiversity", the 2nd research priority "Understand responses to global change and adaptation to change" and the 5th priority "Understand social, economic and policy drivers". More particularly, the sub-priorities identified during the EPBRS workshop were:

1. Gather knowledge on the links between natural assets, ecological traits and function, ecosystem functions, ecosystem services, benefits for humans and human well-being.

   o Particularly important for EU biodiversity strategy Target 2 with the inclusion of social, economic and environmental valuation.

2. Improving capacity, efficiency and usefulness of scenario-building by: 1) improving quality and quantity of primary data, 2) increasing the amount of potential users by improved "user-friendliness" and broadened applicability, 3) integrating adaptive management approaches, and 4) improving knowledge on how to accept, handle and communicate uncertainties.

   o Important for EU biodiversity strategy Target 5 ; research on this issue should help to develop risk assessment systems, including early warning systems for biological invasions

3. Explore the role of the biodiversity components in global change mitigation and adaptation strategies

   o Particularly important for EU biodiversity strategy Target 6, specifically research on best management practices in overseas areas

4. Explore the applicability of existing approaches, tools and technologies for emerging challenges, needs and purposes of different scientific disciplines.

5. Understanding long-distance cause-effect-relations (related e.g. to changes of species assemblages, gene pools, ecological interactions and evolutionary processes) caused for instance by trade, transport, travelling, and changes in species migration patterns

   o Particularly important for EU biodiversity strategy Target 5 ; specifically research on this issue should improve risk assessments for biological invasions

- **Area 4 : Underlying causes of biodiversity loss linked to life-style, economies and human well-being**

This corresponds largely to the 5th priority identified above "Understand social, economic and policy drivers". More particularly, the sub-priorities identified during the EPBRS workshop were:

1. Better understand perceptions and values of biodiversity, and the links between biodiversity "quality", the quality of human well-being and wealth generation.

   o Important for EU biodiversity strategy target 3, particularly for foresters and farmers.

2. Better understand the human behavioural patterns and decision-making process in relation to biodiversity use and conservation, with the aim of promoting a more sustainable lifestyle. Better understand how choices are

made (from individuals and business to government policies) and how our choices in turn impact on biodiversity and ecosystem services. In this respect, we need to understand what motivates people in their decision-making, their perceptions of risks and benefits when making choices, the possible trade-offs inherent in their choices, and the trans-generational implications of those choices.

- Particularly important for EU biodiversity strategy Target 4, specifically research on how to influence consumer behaviour and behavioural choice.

- Also important for EU biodiversity strategy Target 6, specifically research on the effect of business decisions and economic behaviour of the market.

3. Analyse the underlying mechanisms between knowledge, education and the discourses, actions or choices of individuals, businesses and governments.

- **Area 5 : Conservation and sustainable use of natural resources**

This is very close to the 4th priority identified above "Support to sustainable use". More particularly, the sub-priorities identified during the EPBRS workshop were:

1. Further development of methods and instruments for managing human interactions with ecological systems, taking better account of complex and non-linear dynamic processes.

- Particularly important for EU biodiversity strategy Target 2

2. Research on accounting for and mapping ecosystem services and natural capital, recognizing multiple uses of space and the combined impacts of multiple pressures.

3. Research into opportunities for restoration of socio-ecological systems, including best practices, success criteria and indicators, estimation of benefits for local and global stakeholders, and institutional mechanisms for long-term stewardship of restored socio-ecological systems.

4. Research on governance for conservation and sustainable use of biodiversity, in particular developing effective methods for mainstreaming biodiversity across all related sectors.

- Particularly important for EU biodiversity strategy Target 3: specifically with emphasis on synergistic and antagonistic effects within and across EU policies

5. Research on the global environmental and biodiversity impacts of EU consumption patterns, imports and exports, and of EU policies including forestry, fisheries, trade, environment, etc. (i.e. Global footprint of the European Union).

- **Area 6 : Innovative ways of doing research**

This covers well the set of 7 priorities identified above as key principles and enabling actions for biodiversity research, though it includes additional aspects (e.g. Promote meta-analysis on and synthesis, and Using high-tech for research). This area provides cross-cutting critical recommendations relevant for all targets of the EU 2020 Biodiversity Research Strategy, in particular:

1. Synthesis of existing knowledge and information: making better use of what is there, including:

   - Promote meta-analysis on and synthesis of existing biodiversity data, for example using existing centres in Europe like the CESAB in France.
   - Biodiversity informatics – e-research experiments on existing data.
   - Macro-ecological patterns of biodiversity at regional and global scales.

2. Using high-tech for research

   - Apply innovative remote sensing technologies: e.g. equip wild boars with sensors to report on the status of the forest. –
   - Realtime monitoring of biodiversity using most advanced technologies – this could also contribute to developing technological innovations.
   - Apply (meta-)genomic biomonitoring developed for soil communities to other components of biodiversity.

3. Transdisciplinary and participatory research: involve policy makers and other stakeholders and to ensure science addresses policy and public concerns.
   - Increase the amount of trans- and multidisciplinary projects – building on the systematic analysis of what is needed to foster more such research.
   - Ensure that science-policy interfaces are integrated and functional from the beginning of projects, and operate beyond the lifetime of the project.
   - Develop citizen science as a research method, including the ethical aspects to ensure citizens do not get frustrated by badly conducted citizens' science, while science quality is not jeopardized by the approach.

- Integrate science-science, science-policy, science-society dialogue in projects, also consider involving writers, artists and philosophers and the educational sector as well as practitioners and citizens. This will help broaden the perspective on the issues involved.
- Multiple evidence base – combine different types of knowledge, and develop methodologies to integrate them.

4. Collaborative adaptive management

- Collaborative adaptive management: closely coupling the knowledge-sharing loop between research and policy/management, in order to design robust management actions and learn quickly and efficiently from their consequences on the socio-natural system.
- Policy impact assessment and analysis (ex-ante + ex-post)

5. Innovative funding and calls for proposals:

- More open calls focused on broader objectives (rather than tailored for one or very few projects), leaving more room for diversity and innovation amongst the different applications.
- Crowd-funded research projects: possibly combined with direct democracy, where citizens can decide where their taxes go. As a first step crowd-funded projects could be fostered (e.g. by complementing their funding. Offering tax deductions, etc).

It should be noted that specific recommendations relevant for Target 1 were delivered following an EPBRS meeting organized in 2013 in Dublin[3].

3.2 Outcomes of the Alter-net 2013 Conference: "Science underpinning the EU 2020 Biodiversity Strategy"

The primary focus of the conference was to provide scientific knowledge for the implementation of the EU 2020 Biodiversity Strategy, e.g. by pointing out possible weaknesses, opportunities and necessities, and by helping to find solutions and evidence-based actions. This exercise resulted in extensive list of 100 recommendations[4]. From these recommendations, six final and principal ones were distilled – one for each European target. They were deemed by conference participants to be the most urgent and important requirements to enable Europe to meet its biodiversity targets for 2020 and beyond. These six headline recommendations include:

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[3] Full report available at: http://share.bebif.be/data/EPBRS/EPBRSIE/EPBRS-IE2013-EUBD2020targets_Final.pdf

[4] Additional recommendations can be found in the conference report at: http://www.alter-net.info/outputs/conf-2013/outcomes

- **Target 1** (Conserving and restoring nature)
  Natura 2000 success depends primarily on ecosystem health, together with genetic health of its species and populations, rather than on present-day distribution patterns of specific species and habitats; in the end, ecosystem health and genetic population health are important for human well-being in general.

- **Target 2** (Maintaining and enhancing ecosystems and their services)
  Mapping ecosystems and valuing their services is seen as important for improving the knowledge base about nature and social-ecological systems, but to avoid true merchandising of biodiversity, the use of monetary valuation and economic instruments should be limited to areas and situations where the monetary information is necessary for triggering conservation behaviour.

- **Target 3** (Ensuring the sustainability of agriculture and forestry)
  Knowing which problems need standard approaches and which need targeted policy instruments is vital for the development and application of effective biodiversity conservation on managed lands. To advance sustainable agriculture and forestry, engaging the sector actors should be supplemented with standard best practices to solve well-understood general problems as well as innovative and diversified solutions to solve specific and geographically limited problems. Research should support also the monitoring and evaluation of these different types of problems and solutions.

- **Target 4** (Ensuring the sustainability of fisheries)
  Science is the engine to generate adaptive management tools to optimise sustainable fisheries; rather than management based on a single species (among which the present-day minimum size approach for harvesting), ecosystem based fisheries management should be generally implemented.

- **Target 5** (Addressing the problem of invasive alien species)
  Policy should aim at the broad impact of Invasive Alien Species and their interaction with native biodiversity, - health and food production rather than on the sole fact of being alien as criterion for combating details: the first short-term challenge is to develop legal and economic instruments, which are currently being worked on by the policy makers. The second challenge is to fill in the legal instruments with help of combining scientific efforts when it comes to integrating and linking different databases, web portals and other data collections.

- **Target 6** (Addressing the global biodiversity crisis)
  The price of food, fibre and water should encompass both the production and maintenance cost of the ecosystem.

The classification developed through the analysis of strategic documents covers the recommendations of the EPBRS workshop that goes into more detailed priorities. The innovative ways of doing research identified during the EPBRS workshop bring some more suggestions on principles and enabling actions that will be critical for future research efforts. The 100 recommendations generated by the Alter-Net conference

cover a wide scope and go beyond research recommendations. The main selected ones (one per target) can be linked to our classification and emphasize some more detailed needs for effectively implementing the EU biodiversity strategy.

4   Synthesis of current priorities identified for research on biodiversity

Figure 1 summarizes the priority research themes identified above through the analysis of key international and European biodiversity research strategies, key environmental policy documents, and outputs of key European events organised to identify major priorities for biodiversity research. From this analysis, we destile two major headlines:

- **Biodiversity as an increasingly strategic domain of research to support the sustainability and innovation capacity of human societies and their capacity to face future choices and trade-offs**
  Overall, the 7 major research priorities identified above mainly aim to better understand and predict biodiversity changes at all levels (from genes to species and ecosystems) and to investigate the potential consequences of these changes on human activities and well-being. Investigating how humans and societies depend on biodiversity will hopefully help to develop the capacity of our societies to face future choices and trade-offs.
   Similarly, research on conservation and management for sustainable use of natural resources will also be critical to address major questions related to the sustainable management of landscapes and seascapes in the face of growing pressure from multiple usages (e.g. better management and use of agro-biodiversity by and for agriculture at field to landscape scales, and better management of fish stocks via an ecosystem approach). These areas of research will build on knowledge on drivers of biodiversity change, underlying causes and associated ecosystem services. They will also require extensive investigation of adaptive governance and management, as well as research on innovative conservation, management and restoration solutions.

- **Opportunities to shape biodiversity research as an open domain efficiently addressing major societal challenges**
  An important result of our synthesis is the identification of 7 key enabling principles highlighted in most documents analysed, which should be accounted for while strategically shaping biodiversity research in Europe. These include the promotion of multidisciplinary networks and interdisciplinary approaches; engagement of stakeholders and use of participatory processes; effective science-policy and science-society interfaces; communication and translation of scientific knowledge into management practices and policy support; and support for biodiversity research infrastructures, ensuring open access to data. These principles should also be promoted through education and career management to ensure scientists have opportunities and incentives to effectively implement them.

Figure 1: Summary of the analysis of international and European policy priorities, leading to identify 7 research priorities and 7 principles and enabling actions for biodiversity research
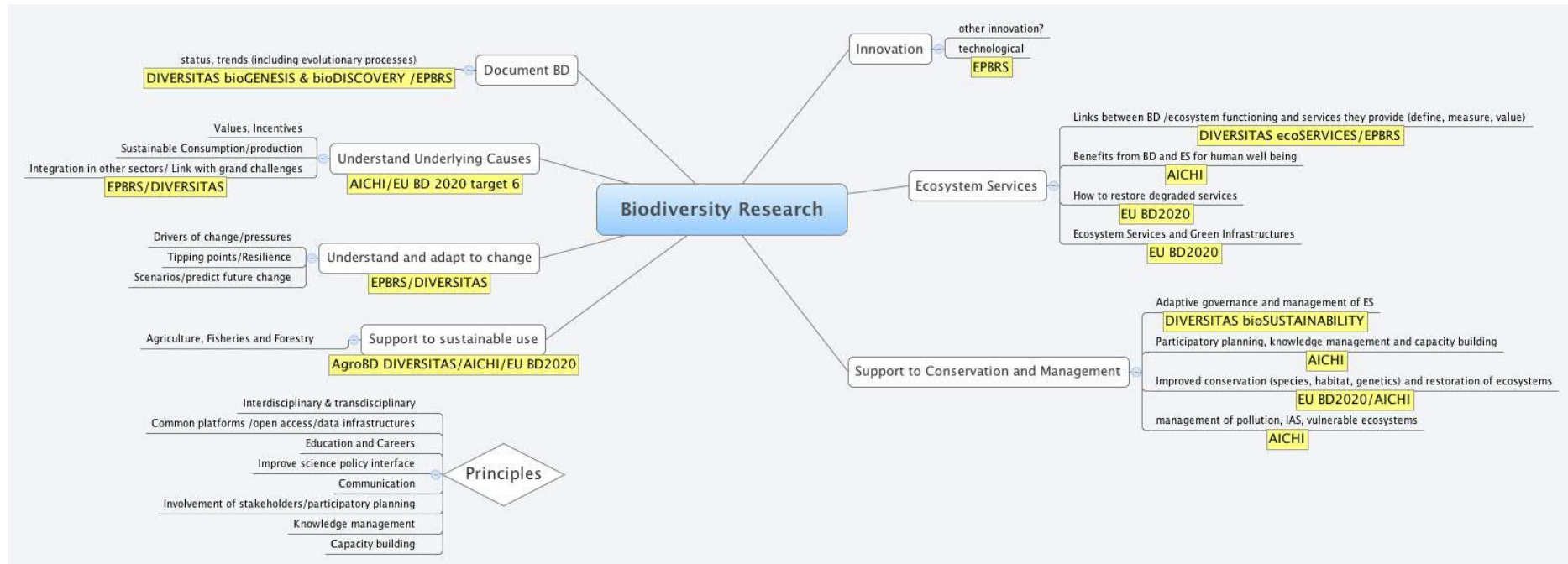
5   Nature-Based Solutions: an emerging priority for biodiversity research – results from a BiodivERsA Strategic foresight workshop

Along with the EU Biodiversity Strategy to 2020, the "nature-based solutions" concept has been emerging, calling for renewed needs of knowledge and actions. As a consequence BiodivERsA partners considered this topic as a major emerging issue for the biodiversity research community, and organised a strategic foresight workshop in June 2014, in particular to identify research needs relevant to Nature-Based Solutions.

The "nature-based solutions" concept refers to the use of nature in tackling challenges such as climate change, food security, water resources, disaster risk management, etc. The purpose of the "nature-based solutions" concept is to encompass a wider definition of how to conserve and use biodiversity in a sustainable manner. By going beyond the threshold of traditional biodiversity conservation principles, this concept intends to additionally integrate societal factors such as poverty alleviation, socio-economic development and efficient governance principles. The International Union for Conservation of Nature (IUCN) is currently developing guidance on what type of interventions could/ should/ should not be considered as a "nature-based solution" (NBS). Other groups are also discussing the definition of the concept of NBS such as the Horizon 2020 Advisory Group (AG) for Societal Challenge 5 'Climate Action, Environment, Resource Efficiency and Raw Materials'.

 Examples of nature-based solutions are provided below:
- Naturally connected floodplains and riparian ecosystems can provide flood protection for millions of people who are likely to experience increased flood risk
- Forest protection and reforestation can provide clean water, reduce flood risk and support carbon sequestration.
- Deep-rooted, nitrogen-fixing plants can naturally replenish soil nutrients in systems helping to maintain access to food supplies. Plants can help filter sediments and nutrients keeping our waters clean and available for human consumption while enhancing carbon sinks.
- Mangrove forests provide protection services from coastal erosion and protect human lives in the face of severe storms while providing nurseries for fishes which can feed coastal populations of people.
- Well-managed and conserved grasslands can provide forage for livestock while storing carbon in above- and below-ground biomass.

Yet, more research and adequate implementation strategies are needed to investigate nature-based solutions, and to further explore how societies can avoid degrading their natural environment and the wealth of valuable benefits it provides. As a consequence, the Horizon2020 program of the European Commission (EC) is expected to tackle nature-based solutions in its 2016-2017 phase. Consultations are thus being set-up at a pan-European scale under the umbrella of the EC.

As the concept of nature-based solutions is rising on the research policy agenda, BiodivERsA organized a horizon scanning workshop[5], providing an opportunity for BiodivERsA project

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[5] Full report and list of participants available at: www.biodiversa.org/671

scientists, and programmers and funders of research members of BiodivERsA (including several Ministries) to:

- Learn more about nature-based solutions through discussions with policy makers and a range of stakeholders (NGOs, businesses, practitioners, etc.)
- Assess to what extend nature-based solutions have already been addressed in BiodivERsA-funded research projects
- Discuss how these nature-based solutions could be further investigated in the field of interest of participants. Such an exercise could produce lists of potential research priorities that could be considered by BiodivERsA's strategic agenda

It was expected that the workshop would help identifying potential research priorities that could be considered by BiodivERsA's strategic agenda in the future. Here, we report on the main results in terms of (i) framing the emerging concept of nature-based solutions and (ii) research priorities identified.

5.1 Framing the concept of NBS and its applications

Main framing conditions to take into consideration when developing nature-based-solutions:

- **A large part of the NBS, solutions should be based on the integration of several levels of diversity within a system** which empowers the socio-ecological systems in terms of sustainability, and resistance and resilience capacity to global changes and extreme/unexpected events. E.g: a forest, which is diverse (from a genetic point of view, age structure, community composition and habitats), could be more prone to resist to hazards like pests, severe drought spells or storms.

- **A NBS should account for multiple interests in particular economic, environmental, and societal ones,** as it should be a tool to provide input for different policies through the understanding of social and economic benefits in addition to environmental ones. NBS research should thus provide knowledge supporting choices and decision making by stakeholders, including policy-makers, through the understanding of social and economic benefits and drawbacks in addition to environmental ones. A key word here is sustainability, because NBS should correspond to sustainable solutions.

- **Identification and documentation of the possible synergies and trade-offs between the multiple economic, environmental, and societal interests is at the heart of the identification and implementation of robust and efficient NBS**. The identification of trade-offs can be facilitated by the results of a risk assessment.

- **Other types of knowledge should be included when exploring NBS**, in particular one cannot ignore 'local knowledge' in identifying NBS.

- The NBS concept requires a **clear link with other concepts such as Green and Blue Infrastructures (GBI), Ecosystem based adaptation to climate change, Ecosystem approaches, Natural Capital, and Ecological Engineering**. For instance, GBI can be part of NBS or NBS can be used to build adequate GBI.[6]

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[6] The research programming process should thus make the links between these different concepts very clear to ensure consistency and avoid redundancy or confusion between programming actions at EU and national scales.

Innovative social processes:

Innovative social processes are needed for NBS implementation but also to a large extent when conducting NBS-relevant research. Specific NBS are indeed tightly linked to the social process needed to identify, assess and organize solutions. The quality of the solutions is thus considered to be dependent on the quality of these social processes, e.g. regarding involvement and support of a diversity stake- and knowledge-holders. More particularly, the following points have been identified as being crucial for successful NBS implementation:

- **Involve relevant stakeholders from the very beginning of the nature-based solution process**, in particularin the following steps: (i) Identification of the problem and possible NBS (ii) Identification of the natural and social processes occurring; (iii) Knowledge building; and (iv) Information gathering and dissemination (see below). In particular, interdisciplinarity/ transdisciplinarity should be a Nature-Based Solutions rule.

- **Knowledge on NBS needs to be made widely available and shared.** In this context, how results of NBS-relevant researches are reaching out to their audience is critical and requires that the message is reframed depending on the targeted audience. Both good and bad examples should be reported from various geographical areas (e.g. not just in developing countries but also in developed ones). NBS are often case-specific and may not be easily transferred to other settings, but some ideas can be useful in various contexts.

Avoid misleading conceptions and approaches when framing the NBS topic:

- **NBS are referred to as 'Innovative' but should not only refer to 'new' solutions** : NBS might be a new concept but it encompasses already existing ideas; there might be innovative components in "old ways"; it is important to learn from the past and look back at what has been done to identify potential future NBS.

- **NBS are not THE solution to all problems, and will not necessarily offer simple solutions to complex problems. It is important to clearly define the problem that could be targeted**. For complex problems, the views of a range of stakeholders might be collected, and negotiation involving relevant stakeholders might be organised to avoid only simple solutions which would not tackle the whole issue. Depending on the problem identification, NBS can be looked at through building blocks (e.g. landscape approaches).

- **Do not propose and implement a NBS without an associated sound risk assessment** (and possibly a Plan B) taking into consideration a life cycle analysis and the precautionary principle. For instance, NBS need to account for future environmental changes and especially all proposed NBS should be evaluated for being "climate proof" and "biodiversity proof"**.** The analysis should cover the full set of impacts (Climate Change, Biodiversity, Social well-being) but also current lines of production to avoid « wrong » solutions e.g. biofuels. Indeed, a NBS solution may – at some point – become a problem.

5.2 *Proposed typology of NBS*

BiodivERsA workshop participants proposed to categorize NBS along two gradients (Figure 2):

(1) "how much engineering of biodiversity and ecosystems is involved by a given NBS"; and
(2) "how many services and stakeholder groups are targeted by a given NBS ". It is expected that the higher the number of services and stakeholder groups, the lower the capacity to maximize each service and fulfil the specific needs of a particular stakeholder group

Using these two gradients, 3 main types of NBS were defined:

1- NBS Type 1: They consist in better using existing natural or weakly managed ecosystems; the ambition here is to better use them, delivering a range of ecosystem services in and outside these ecosystems while minimising the intervention on the systems themselves.
2- NBS Type 2: They correspond to the definition of management rules to develop sustainable and multifunctional ecosystems (possibly intensively managed) and better deliver selected ecosystem services.
3- NBS Type 3: They consist in managing ecosystems in very intrusive ways or even creating completely new ecosystems.
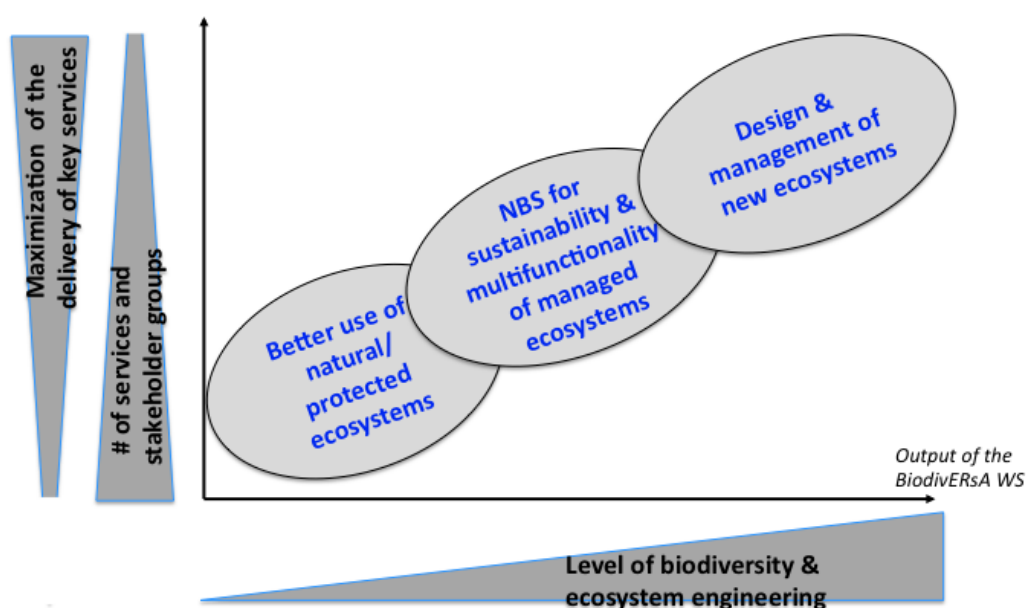
Figure 2: Schematic representation of the range of NBS approaches to be considered. Three main types of NBS are defined, differing in the level of engineering applied to biodiversity / ecosystems (X axis), and in the number of services to be delivered, the number of stakeholder groups targeted, and the likely level of maximization of the delivery of the targeted services (Y axis).

Participants identified some examples of NBS (Figure 3) for each type and some links with existing BiodivERsA projects (Figure 4)
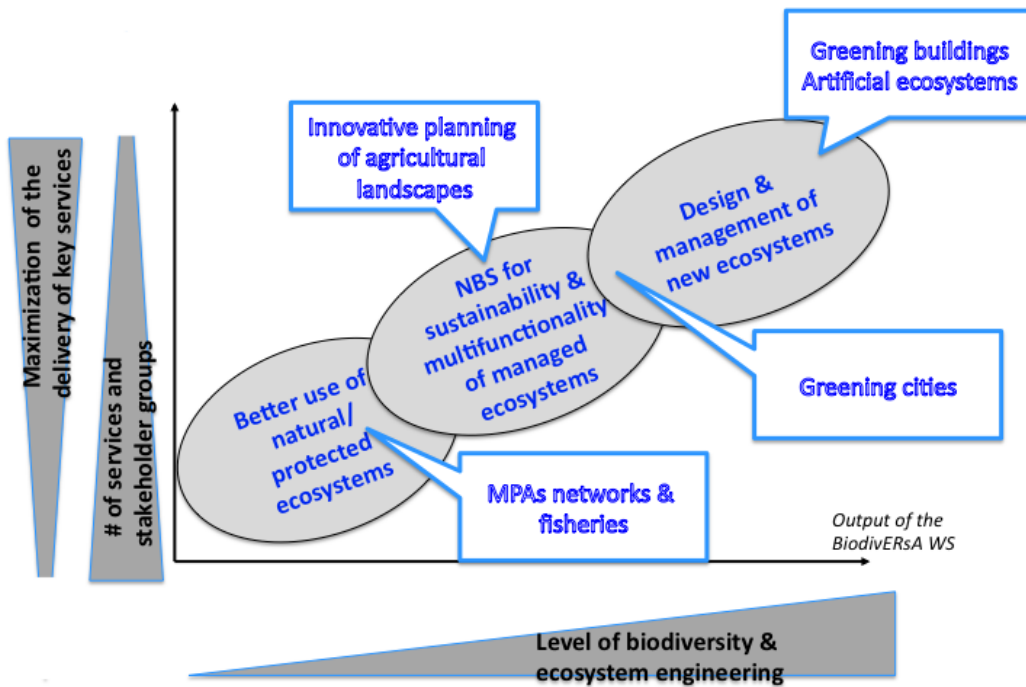
Figure 3: Some examples of NBS located in the schematic representation of Figure 2
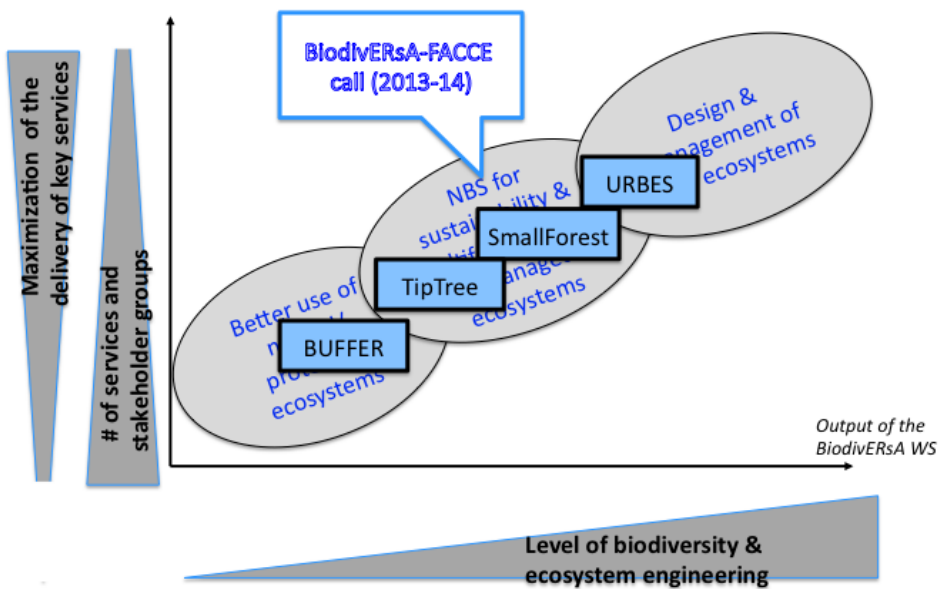
Figure 4: Some examples of NBS-relevant research projects funded by BiodivERsA located in the schematic representation of Figure 2. The type of NBS addressed by the BiodivERsA-FACCE call launched in late 2013 is also indicated.

5.3 Research recommendations related to NBS

5.3.1 Research recommendations related to examples of NBS

The research recommendations identified below are indicative of key areas of research that could be addressed to support the identification and implementation of nature-based solutions. This is not a complete or exhaustive list of research recommendations for each of the mentioned topic, but it is meant as a trigger to stimulate further discussion on NBS.

- **Climate adaptation and mitigation**

    o **Reducing carbon emissions**

    NBS-relevant research on peat land conservation and restoration: Research needs arise with regard to optimal restoration approaches and better understanding of 'if' and 'how' peat land can regain its capacity to mitigate climate change (carbon sequestration and reduction of greenhouse gases) while providing social and economic benefits and preserving biodiversity..

    Research on NBS options to stop or largely mitigate ocean acidification: There are significant knowledge gaps and research needs related to both the natural science involved and the most promising policies to successfully reduce ocean acidification in practise; this may include geo-bio-engineering approaches that would fulfil the NBS concept

    o **Increasing ecosystem resilience**

    One general research need is to ***increase the understanding of the role of Biodiversity for ecosystem resilience*** *as a basis of many NBS*

    o **Greening cities**

    Some remaining research gaps include: What are ***specific contribution of different species, potential and challenges of introducing species, creating new ecosystems***? as greening cities often rely on newly created ecosystems.

- **Sustainable food production and consumption/ Food Security**

    o ***"Research to support Climate- and biodiversity- smart" Food production and consumption*** based on less meat and dairy consumption.

The identified research gaps focussed mainly on socio-economics and policy including questions such as: how can a more "politically viable" reform of Common Agricultural Policy (for the EU, but also globally) be derived?

Specific aspects include: How to achieve more climate and biodiversity benefits through subsidy reforms and other instruments? E.g. taxes

o ***Research on Alternative food sources (e.g. invertebrates)***

There are some knowledge needs related to alternative food sources (e.g. invertebrates) as a (nature-based) solution to reduce the environmental impact of food production:

- Feasibility within and across Europe, both climatically, ecologically and socio-economically of these alternative food sources
- Consumers acceptance is an overruling factor as there is a reluctance to this kind of food, yet many details of this might represent knowledge gaps worthy of further investigation.
- Harvesting techniques & impacts on local biodiversity and ecosystem functioning

o ***Research on copying natural high-productive and resilient systems as a (nature-based) solution for maintaining soil productivity***

Many potential knowledge gaps on natural high-productive systems are related to the domains of soil ecology and biogeochemistry. These are currently very active fields of research, so progress towards nature-based solutions for these issues should be ongoing. In particular, the capacity to manage and even manipulate soil biodiversity to better deliver a range of services and increase ecosystem resistance and resilience to natural hazards still remains a challenge

There might be much to learn from old (forgotten?) agricultural practices. Research into such practices might equally be recommended.

o ***Research to make our food supply/systems sustainable***

In this area, further research would be needed on effectiveness of 'green elements' in enhancing agricultural productivity, pathways used, multi-functionality and long-term sustainability

- **Water production**

  o ***Research on natural filtration systems and buffer zones (reed beds on local scale, wetlands on a wider scale)* as a NBS for water pollution**

The possibility to develop and manage reed beds and wetlands to filter out major nutrients like nitrogen and phosphorus has already been extensively addressed. However, this remains to be addressed for several substances (e.g. **pharmaceuticals),** accounting for effects on ecosystem / species and human health. Where nature-based solutions and especially engineered new ecosystems would be implemented ('NBS sites'), the possibility to favor invasive alien species should be carefully evaluated.

- **Soil/forest/land management**

  o ***Research is needed to further explore integrated spatial planning and management of the landscape mosaic.*** *Among other issues, it will be needed to assess if Green Infrastructures are fit for purpose, e.g. through comparative assessments of current methodologies (especially for population genetics and functional connectivity)*

o ***Research is needed to improve the understanding of resilience of ecosystems (mechanisms/pathways/importance of keystone species…)*** *as a basis for many NBS;* this includes better knowledge of the role of functional and genetic diversity; and a better understanding of community dynamics in anthropogenically modified landscapes.

o ***Research is needed to manage landscape to deliver multiple services, including more efficient control of pests:*** this requires to account for long term dynamics of resilient genotypes, effects of increasing plant/soil diversity, and effects of biological control agents.

5.3.2 General research recommendations related to NBS

In relation to the concept of nature-based solutions, research is needed to:

- Systematically assess the trio of economic, social and environmental benefits/ indicators for human well-being while addressing timescale for delivery of benefits

- Develop cost-effectiveness assessment and financial implications of NBS: This will require focusing on the valuation of some particular elements of ecosystem assessment that are not yet well investigated

- Explore political and social resistance to change what would be needed for implementing some NBS

- Further understand the drivers, correlates and incentives that drive the clash between the socio-economic and the natural environments and that could block a proposed NBS.

- Develop transdisciplinary methods and explore participatory ways of translating and sharing lessons learned on NBS (communication and collaboration with stakeholders)

- Develop risk assessments of NBS, especially for ecological risks

- Conduct research on the governance needed to address the results of NBS risk assessments

- Further understand the ecological processes and relationships between biodiversity/ecosystem functions and ecosystem services to feed potential NBS. There is a need for an understanding of these functions and services but also on how to restore or improve them.

6 Conclusions

The analysis of key international and European policy and research strategies (Section 2) provided the basis for going into more concrete research priorities (Section 3) making use of consultations through various events. The nature-based solutions (Section 5) that are now rising on policy agenda are also embedded in these main research priorities, and clearly link up with the two major headlines identified earlier: (i) biodiversity as an increasingly strategic domain of research to support the sustainability and innovation capacity of human societies and their capacity to face future choices and trade-offs; (ii) opportunities to shape biodiversity research as an open domain efficiently addressing major societal challenges. Exploring NBS seems to provide some more detailed and practical opportunities for innovative research threads that could also interest markets.

Basically, all research recommendations relate to the same key challenge that is specifically focusing on supporting a socio-economic paradigm shift to ensure human survival by preserving the living environment we depend upon. The current socio-economic paradigm aiming to increase the pressure on this living environment to supply even more marketable goods and services without taking into consideration long-term consequences and planetary boundaries must be changed to a truly sustainable and equitable economy and management of natural resources within the limits of the planet's ecosystems resilience. Research and specifically research funding agencies have a key role to play to support this transition through targeted research calls but also through support to building the capacity of the research community specifically on trans- and interdisciplinarity, as a major bottleneck is the joint, integrative work of different actors and sectors in a transdisciplinary way. Developing research needs in such a context is challenging as it requires to develop a very integrative view, accounting not only for the environmental aspects but also the social and economic ones. Trade-offs will clearly need to be explored.

BiodivERsA, as a major European actor of biodiversity and ecosystem services research, has already addressed several of the identified pressing issues in its calls and strategic actions. In its next phase, it will further build on the research priorities such as those identified in this report to develop its future research agenda and contribute to the critical transition described above. In doing so, it will – as before - apply the enabling actions identified in this report, including promotion of interdisciplinary approaches, engagement of stakeholders, efficient science-society and science-policy interfacing, support for biodiversity research infrastructures, and involvement of early career scientist. Such an approach will help building a research community open to societal challenges and able to efficiently address them.

Annex　I

Implementing the DIVERSITAS vision for biodiversity and ecosystem services
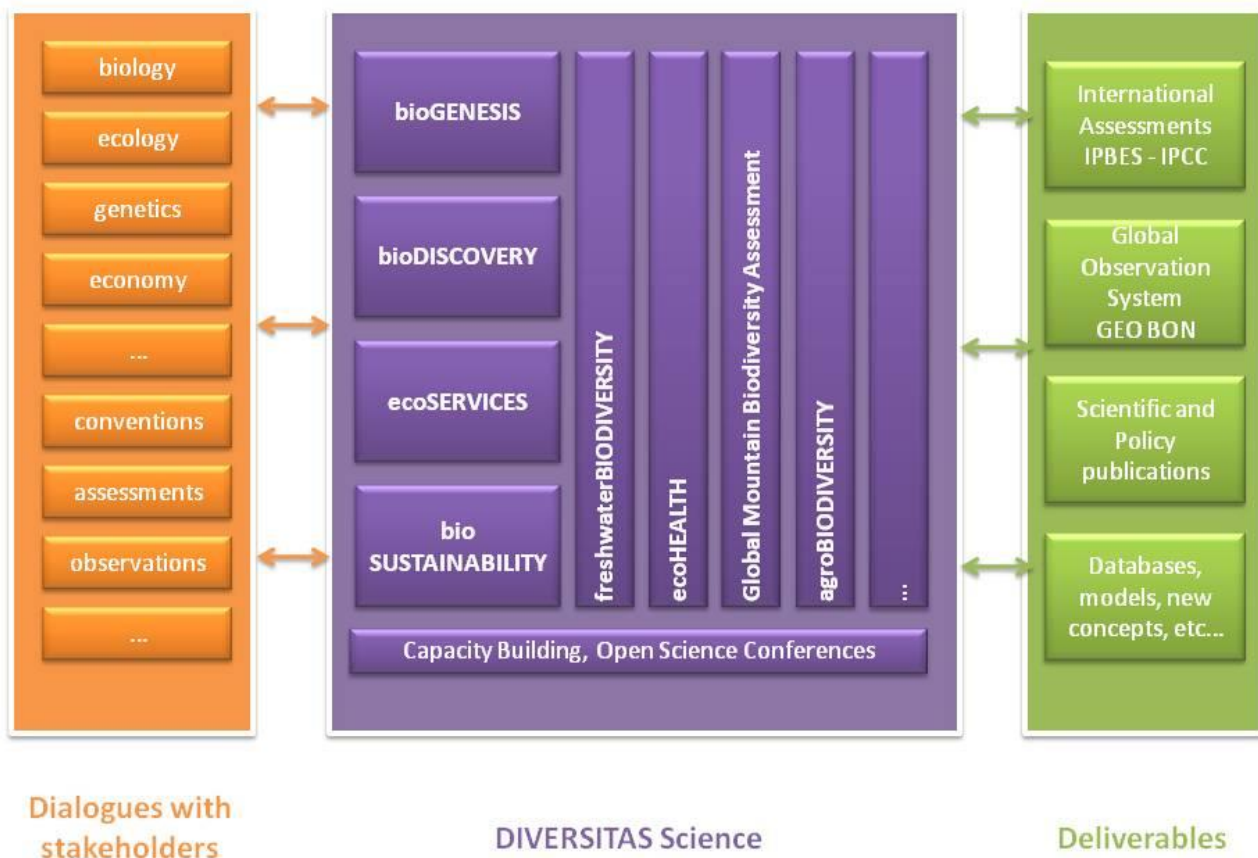
Annex IIa

CBD Action Plan Aichi Targets			EU Biodiversity Communication		
Strategic Goal A: Address the underlying causes of biodiversity loss by mainstreaming biodiversity across government and society	**Underlying causes of biodiversity loss**		**TARGET 1: FULLY IMPLEMENT THE BIRDS AND HABITATS DIRECTIVES**	**Conservation and management**	
›› Target 1: By 2020, at the latest, people are aware of the values of biodiversity and the steps they can take to conserve and use it sustainably.	Underlying causes of biodiversity loss+ Mainstreaming/values		Action 1: Complete the establishment of the Natura 2000 network and ensure good Management	Conservation and management	
›› 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.	Underlying causes of biodiversity loss+ Mainstreaming/values		Action 2: Ensure adequate financing of Natura 2000 sites	Conservation and management	
›› Target 3: By 2020, at the latest, incentives, including subsidies, harmful to biodiversity are eliminated, phased out or reformed in order to minimize or avoid negative impacts, and positive incentives for the conservation and sustainable use of biodiversity are developed and applied, consistent and in harmony with the Convention and other	Underlying causes of biodiversity loss+ Incentives		Action 3: Increase stakeholder awareness and involvement and improve enforcement	Conservation and management	Participatory/stakeholder involvement
›› Target 4: By 2020, at the latest, Governments, business and stakeholders at all levels have taken steps to achieve or have implemented plans for sustainable production and consumption and have kept the impacts of use of natural resources well within safe ecological limits.	Underlying causes of biodiversity loss + sustainable production and consumption		Action 4 Improve and streamline monitoring and reporting	Conservation and management	Knowledge management
Strategic Goal B: Reduce the direct pressures on biodiversity and promote sustainable use	**Sustainable use**		**TARGET 2: MAINTAIN AND RESTORE ECOSYSTEMS AND THEIR SERVICES (By 2020, ecosystems and their services are maintained and enhanced by establishing greeninfrastructure and restoring at least 15% of degraded ecosystems)**	**Ecosystem Services**	
›› Target 5: By 2020, the rate of loss of all natural habitats, including forests, is at least halved and where feasible brought close to zero, and degradation and fragmentation is significantly reduced.	Conservation and management		Action 5: Improve knowledge of ecosystems and their services in the EU	Ecosystem Services	Knowledge management
›› Target 6: By 2020 all fish and invertebrate stocks and aquatic plants are managed and harvested sustainably, legally and applying ecosystem based approaches, so that overfishing is avoided, recovery plans and measures are in place for all depleted species, fisheries have no significant adverse impacts on threatened species and vulnerable ecosystems and the impacts of fisheries on stocks, species and ecosystems are within safe ecological limits.	Sustainable use		Action 6: Set priorities to restore and promote the use of green infrastructure	Conservation and management	GREEN INFRASTRUCTURES
›› Target 7: By 2020 areas under agriculture, aquaculture and forestry are managed sustainably, ensuring conservation of biodiversity.	Sustainable use		Action 7: Ensure no net loss of biodiversity and ecosystem services	Conservation and management	Ecosystem Services
›› Target 8: By 2020, pollution, including from excess nutrients, has been brought to levels that are not detrimental to ecosystem function and biodiversity.	Sustainable use		**TARGET 3: INCREASE THE CONTRIBUTION OF AGRICULTURE AND FORESTRY TO MAINTAINING AND ENHANCING BIODIVERSITY**	**Sustainable use**	
›› Target 9: By 2020, invasive alien species and pathways are identified and prioritized, priority species are controlled or eradicated, and measures are in place to manage pathways to prevent their introduction and establishment.	Sustainable use		Action 8: Enhance direct payments for environmental public goods in the EU Common Agricultural Policy	Sustainable use	
›› Target 10: By 2015, the multiple anthropogenic pressures on coral reefs, and other vulnerable ecosystems impacted by climate change or ocean acidification are minimized, so as to maintain their integrity and functioning.	Sustainable use		Action 9: Better target Rural Development to biodiversity conservation	Sustainable use	Conservation and management
Strategic Goal C: Improve the status of biodiversity by safeguarding ecosystems, species and genetic diversity	**Conservation and management**		Action 10: Conserve Europe's agricultural genetic diversity	Sustainable use and management	Conservation and management
›› Target 11: By 2020, at least 17 per cent of terrestrial and inland water, and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically	Conservation and management		Action 11: Encourage forest holders to protect and enhance forest biodiversity Action 12: Integrate biodiversity measures in forest management plans	Sustainable use	
›› Target 12: By 2020 the extinction of known threatened species has been prevented and their conservation status, particularly of those most in decline, has been improved and sustained.	Conservation and management		**TARGET 4: ENSURE THE SUSTAINABLE USE OF FISHERIES RESOURCES**	**Sustainable use**	
›› Target 13: By 2020, the genetic diversity of cultivated plants and farmed and domesticated animals and of wild relatives, including other socio-economically as well as culturally valuable species, is maintained, and strategies have been developed and implemented for minimizing genetic erosion and safeguarding their genetic diversity.	Conservation and management	Sustainable use	Action 13: Improve the management of fished stocks	Sustainable use	
Strategic Goal D: Enhance the benefits to all from biodiversity and ecosystem services.	**Ecosystem Services- Benefits from ES**		Action 14: Eliminate adverse impacts on fish stocks, species, habitats and ecosystems	Sustainable use	
›› 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.	Ecosystem Services- Benefits from ES		**TARGET 5: COMBAT INVASIVE ALIEN SPECIES**	**Sustainable use**	
›› 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.	Ecosystem Services- Benefits from ES		Action 15: Strengthen the EU Plant and Animal Health Regimes	Sustainable use	
›› Target 16: By 2015, the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization is in force and operational, consistent with national legislation.	Ecosystem Services- Benefits from ES	Sustainable use	Action 16: Establish a dedicated instrument on Invasive Alien Species	Sustainable use	
Strategic Goal E: Enhance implementation through participatory planning, knowledge management and capacity building	**Participatory, knowledge management, capacity building**		**TARGET 6: HELP AVERT GLOBAL BIODIVERSITY LOSS**	**Underlying causes**	
›› Target 17: By 2015 each Party has developed, adopted as a policy instrument, and has commenced implementing an effective, participatory and updated national biodiversity strategy and action plan.	Participatory, knowledge management, capacity building		Action 17: Reduce indirect drivers of biodiversity loss	Underlying causes	
›› Target 18: By 2020, the traditional knowledge, innovations and practices of indigenous and local communities relevant for the conservation and sustainable use of biodiversity, and their customary use of biological resources, are respected, subject to national legislation and relevant international obligations, and fully integrated and reflected in the implementation of the Convention with the full and effective participation of indigenous and local communities, at all relevant levels.	Participatory, knowledge management, capacity building		Action 18: Mobilise additional resources for global biodiversity conservation	Funding	
›› Target 19: By 2020, knowledge, the science base and technologies relating to biodiversity, its values, functioning, status and trends, and the consequences of its loss, are improved, widely shared and transferred, and applied.	Participatory, knowledge management, capacity building		Action 19: "Biodiversity proof" EU development cooperation	Underlying causes + mainstreaming	
›› Target 20: By 2020, at the latest, the mobilization of financial resources for effectively implementing the Strategic Plan 2011- 2020 from all sources and in accordance with the consolidated and agreed process in the Strategy for Resource Mobilization should increase substantially from the current levels. This target will be subject to changes contingent to resources needs assessments to be developed and reported by Parties.	Funding		Action 20: Regulate access to genetic resources and the fair and equitable sharing of benefits arising from their use	Ecosystem Services- Benefits from ES	Sustainable use

Annex IIb

EPBRS Research Strategy			DIVERSITAS Science Plan			DIVERSITAS New Strategic Plan		
2.1 – Ensure the long-term survival of species, their genetic diversity, and the ecological integrity and functionality of habitats and ecosystems	Conservation and management		Biodiscovery: DISCOVERING BIODIVERSITY AND PREDICTING ITS CHANGES	Understand and Adapt to change		challenge 1 Identify critical detrimental changes in biodiversity and ecosystem services and provide the knowledge to avoid, limit or mitigate such changes	Understand and Adapt to change	
2.1.1 Assess status and trends, functional reltionships	Documenting biodiversity		Focus 1.1 Assessing current biodiversity	Documenting biodiversity		Develop assessment, monitoring tools, and reporting systems to detect detrimental change in biodiversity and ecosystem services as well as identify components, services, and people at risk, especially those underimmediate threat;	Understand and Adapt to change	
2.1.2 Improve understanding of drivers and mechanisms of change	Understand and Adapt to change	Documenting biodiversity	Focus 1.2 Monitoring biodiversity changes	Understand and Adapt to change		Improve understanding of and methods to identify drivers of change in order to design well-targeted interventions to tackle the changes identified;	Understand and Adapt to change	
2.1.3 Improve understanding and develop guidance for effective management, conservation and resotration of biodiversity and ecosystem services	Conservation and management	Sustainable use	Focus 1.3 Understanding and predicting biodiversity changes	Understand and Adapt to change		Develop interventions (including adaptation) to avoid, mitigate, and limit impacts, and to restore systems. Interventions include technological, ecological, social,and economic solutions.	Understand and Adapt to change	
2.2 – Ensure the long-term provision of ecosystem services	Ecosystem Services		EcoServices: ASSESSING IMPACTS OF BIODIVERSITY CHANGES	Ecosystem Services	Understand and Adapt to change	Chanllenge 2 Enhance the capacity of social–ecological systems to support biodiversity and ecosystem services under global change	Sustainable use	Underlying causes + Mainstreaming
2.3 – Adapt to global change (including climate change)	Understand and Adapt to change		Focus 2.1 Impacts of biodiversity changes on ecosystem functioning and ecosystem services	Ecosystem Services	Understand and Adapt to change	Build the knowledge base for management practices that enhance the ability of current social–ecological systems to maintain biodiversity and ecosystem services.	Sustainable use	
2.4 – Contribute to meeting other Grand Challenges (water, food, energy security, population growth, human health)	Underlying causes + Mainstreaming		Focus 2.2 Impacts of biodiversity changes on health	Ecosystem Services	Understand and Adapt to change	Enhance the governance capacity of social–ecological systems to reflect, cope with, and shape the evolving dynamics of biodiversity over the long term, including building transformative capacity and the consequences for the equitable access to ecosystem services by local and global human populations.	Underlying causes + Mainstreaming	
2.5 – Foster technological and product innovation	INNOVATION		BioSustainability: Building adaptive governance, Management of Ecosystem Services	Conservation and management	Sustainable use	Challenge 3 Develop an understanding of the patterns, trends, origins and functions of biodiversity and their underlying drivers to enable effective interventions to preserve unique elements and sustain human well-being	Documenting biodiversity	
3 – Integrated research	Interdisciplinary-transdisciplinary research		Focus 3.1 Evaluation of the effectiveness of conservation measures and incentives for achieving the conservation and sustainable use of biodiversityFocus 3.2 Establishing scientific approaches for optimising multiple uses of biodiversity, considering possible trade-offs between economic and environmental goals, and the uncertainty associated with novel developments	Conservation and management	Sustainable use	Quantify status and trends in global biodiversity.	Documenting biodiversity	
• Area A: To assess the status and trends of biodiversity, and associated ecosystem services, the exploitation of these services, and the benefits accruing from them and the costs and consequences of not adequately protecting them, complemented by improving our knowledge of human perceptions, attitudes and values towards biodiversity and the services provided by ecosystems.	Documenting biodiversity	Ecosystem Services	BioGenesis: Documenting biodiversity, causes and consequences of diversification, evolutionary processes	Documenting biodiversity		Gain a robust predictive understanding of the evolutionary and ecological mechanisms that drive the generation and organisation of biodiversity at genome, species, community, and ecosystem levels at different spatial and temporal scales.	Documenting biodiversity	
• Area B: To improve the understanding of the indirect and direct drivers of biodiversity change and their influence on the functioning of ecosystems and the services they provide.	Understand and Adapt to change	Underlying causes	AgroBiodiversity	Sustainable use		Gain an understanding of how human actions (direct and indirect, e.g. through land use or climate change) impact on mechanisms that drive generation and organisation of biodiversity at different levels and how these actions contribute to maintaining or changing biotic diversity	Underlying causes + Mainstreaming	
• Area C: To improve implementation and evaluation of policy, governance, and specific measures for the conservation of biodiversity and ecosystem services as well as the sustainable use of natural resources	Conservation and management	Sustainable use	EcoHealth	Ecosystem Services		Challenge 4 Build an effective global network of biodiversity science	Participatory, knowledge management, capacity building, infrastructures, science policy interface	
4 – Developing the research environment			Freshwater Biodiversity	Conservation and management	Sustainable use	Foster the involvement of scientists from all geographical regions of the world, in particular from highbiodiversity countries; ensure a balanced	Participatory, knowledge management, capacity building,	
• Further develop close collaboration and cooperation with all appropriate stakeholders;	Participatory/engagement stakeholders		Global Mountain	Conservation and management	Sustainable use	Identify and ensure the involvement of all relevant disciplines and continue to promote an interdisciplinary approach (both within and between the natural and social sciences);	Interdisciplinary/transdisciplinary	
• Further develop links between science and public engagement networks like natural history museums, science centres and citizen science programmes	Participatory/engagement stakeholders					Recognise and respect the contribution of indigenous and local knowledge to biodiversity science and use, and, where necessary, develop ways to allow the full use of this knowledge;	Participatory/ engagement of stakeholders	
• Devotion of significant resources devoted to appropriate communication of research results and their applications in cooperation with stakeholders, at all scales, including the global;	Science policy interface					Identify and ensure the involvement of scientists who work across sectors of society, that is, transdisciplinary scientists, especially those working at the interface between science and policy	Interdisciplinary/transdisciplinary, science policy interface	
• Further develop, network and deploy infrastructure for monitoring and assessment, open access databases, and virtual institutes for data exchange and analyses and other elements of modern infrastructure.	Infrastructures							
4.1 – Continuous identification, review and horizon scanning of research priorities	Knowledge management							
4.2 – Support common infrastructures and platforms – on the European as well as the international scale	Infrastructures							
4.3 – Promote education and career in the field of biodiversity	Capacity building							
4.4 – Build the links between science and Policy	Science policy interface							
4.5 – Evaluate biodiversity research in Europe and monitoring its use	knowledge management							