

BIODIV'2050 OUTLOOK:



Global Biodiversity
Score: measuring a
company's biodiversity
footprint

N°11 - November 2017

CONTENTS

INTRODUCTION	3
1. Origins of the project	5
1.1 Historical overview of CDC Biodiversité's research around the theme of "business and biodiversity"	5
1.2 Purpose of the project	5
2. Search for complementarity with national and international initiatives on the issue of biodiversity footprint	7
2.1 International initiatives	7
2.2 French national initiatives	8
2.3 Ongoing projects closely related to biodiversity footprint	9
3. Global Biodiversity Score: objectives, required characteristics and general presentation	11
3.1 Desired features of the GBS™	11
3.2 Desired specifications for biodiversity input data used for the GBS™ methodology	12
3.3 Overview of existing data complying with specifications laid down	12
3.4 Justification for selecting GLOBIO model data	14
3.5 General overview of GBS	16
4. Focus on biodiversity input data from the GLOBIO model used in the GBS™ methodology	19
4.1 The GLOBIO model's biodiversity indicator: MSA	19
4.2 General overview of the GLOBIO model	20
5. GBS™ methodology: first step on the biodiversity footprint of raw materials	27
5.1 Input biodiversity data used	27
5.2 The reallocation of impacts to economic sectors	27
5.3 Application to an agricultural commodity: soya	32
5.4 Limits relating to the biodiversity footprint of raw materials	34
6. GBS™ methodology: on-going developments and future challenges	35
6.1 On-going developments	35
6.2 Future challenges	38
CONCLUSION AND PROSPECTS	39
GLOSSARY	40
APPENDICES	41
BIBLIOGRAPHY	43

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EDITORIAL

While the quest for a single indicator capable of measuring the environmental footprint of economic activities was long believed to be a vain pursuit, it is now poised to shake up the business world.

The outstanding consequences generated by the development of carbon dioxide equivalent metrics in terms of awareness raising and climate change mitigation policies structuration provide a striking example of the catalysing role that a single biodiversity reference indicator could have. To reach the same level of mobilization for biodiversity, there is a need for a similar approach based on a simple and comprehensive indicator. However, it is of crucial importance to keep in mind that such an indicator could at best act as a proxy to address the infinite complexity of the living world and its dynamics.

The emerging movement towards biodiversity-based CSR ratings needs to take into account specific challenges facing businesses. In that context, CDC Biodiversité launched the biodiversity equivalent of the Teq CO₂ for climate change in partnership with businesses and financial institutions. It is based on internationally recognised scientific research.

The objective of such a biodiversity metric is the following. It needs to represent biodiversity for itself, and not through the values or services derived from ecosystems. It has to be transparent and consensual. It has to be easy to estimate and to understand by non-specialists. It has to be expressed with a number. Finally, the efforts of those whose impacts are being measured have to be reflected in the changes of the indicator.

At CDC Biodiversité, we are developing a biodiversity footprint methodology that we called the Global Biodiversity Score (GBS). We are convinced that it meets the relevant conditions mentioned above. Our approach is open and favours partnerships. In order for the methodology to take into account the needs and constraints of each sector, we offer businesses the opportunity to work with us in our Club of Positive Biodiversity Businesses (B4B+ Club) that acts as a platform for the GBS development.

This issue of the Biodiv'2050 Outlook collection is the first publication dedicated to the work which has been done within the B4B+ Club that now comprises more than 20 members. I invite all those interested by this challenge and who desire to engage further to join us in this ambitious journey.

LAURENT PIERMONT
Président de CDC Biodiversité



INTRODUCTION

Biodiversity is our planet's "living tissue" and the ultimate source of all ecosystem services on which human societies depend (supply of raw materials, pollination, air quality, water quality, climate regulation, etc.). It also underpins the capacity of ecosystems to deal with any future disturbances. Our planet is currently witnessing a massive erosion of biodiversity, most apparent in the growing number of species threatened with extinction. Aside from remarkable species, the collapse in the populations of so-called "common" species threatens the very functioning of ecosystems. Biodiversity loss is of concern to all ecosystems everywhere – from pristine tropical forests to agricultural areas and major cities.

Biodiversity is also crucial to the long-term sustainability of economic activities. Most sectors use and therefore depend – either directly or indirectly – on natural resources and ecosystem services. As a result, the current erosion of biodiversity poses a threat to the economic development and stability of our societies. Given the seriousness of the crisis, the international community has started to react. The United Nations (UN) launched the Convention on Biological Diversity (CBD) at the Rio Earth Summit in 1992 to provide a framework and set down objectives for tackling biodiversity loss on a global scale. The 196 Parties to the CBD came up with the Strategic Plan for Biodiversity 2011–2020, broken down into 20 goals known as the

Aichi Targets. The involvement of the private sector is clearly identified as being key, both by incorporating biodiversity into sector-based policies to reduce pressure on ecosystems and by leveraging financial resources. In 2010, the first report by the "High-Level Panel on the Global Assessment of Resources for implementing the Strategic Plan for Biodiversity 2011–2020" estimated that between US\$ 150 billion and US\$ 440 billion would need to be spent every year, *i.e.*, between 0.20% and 0.53% of annual global GDP⁽¹⁾, to stop the erosion of biodiversity⁽²⁾. However, current expenditure on pro-biodiversity initiatives is estimated at only US\$ 50 billion a year (Parker et al., 2012), which represents merely one-eighth to one-sixth of the total amount required.

As such, there are high expectations regarding private sector involvement in tackling biodiversity loss from many different stakeholders, *i.e.*, public bodies, civil society, investors and businesses themselves. This dynamic has a lot in common with what happened regarding climate change a few years ago.

(1) Based on global GDP for 2013, estimated by the World Bank at US\$ 75,621,858 billion. Source: <http://databank.worldbank.org/data/download/GDP.pdf>

(2) The range of estimates is very broad due to the diverse methodologies used to measure costs and potential synergies. Expenditure can contribute to different objectives such as climate change or sustainable agriculture.





Origins of the
project

1

Origins of the project

1.1 Historical overview of CDC Biodiversité's research around the theme of "business and biodiversity"

The links between business and biodiversity have been explored in a series of research projects over the past few years as part of *Mission Économie de la Biodiversité* (MEB), an initiative of *Caisse des Dépôts*, spearheaded and run by CDC Biodiversité⁽³⁾. First off, a qualitative analysis of biodiversity-related risks and opportunities based around the principal economic sectors was used to assess the wide range of situations facing sectors and businesses regarding biodiversity issues (CDC Biodiversité, 2015). This was followed by a comparative analysis of standardized tools that factor in biodiversity and ecosystem services, and that can be used by businesses to mainstream natural capital into decision-making processes. This work was rounded out by the creation of a dedicated app, GoBIODIV+⁽⁴⁾, that uses a question/answer format to guide companies towards the tools best suited to the type of use (strategic, site, product, etc.) and desired level of biodiversity expertise (CDC Biodiversité, 2015).

This body of work has highlighted the drawbacks and limits of existing tools hindering biodiversity mainstreaming by businesses. The first observation is that from a value chain perspective, analytical tools are very rare and exclusively qualitative in nature. Indeed, most quantitative tools are designed for a much narrower analytical base (*i.e.*, production site, building, etc.), the upstream and downstream sections of the value chain being only coarsely considered. The second observation is that biodiversity is mainly examined from an ecosystem services perspective. This has a number of advantages, such as the possibility to analyse dependencies on biodiversity rather than merely biodiversity-related impacts (which provides strategic information on risk management), the cross-cutting nature of the analysis that allows for the incorporation of a number of environmental risk factors (water, carbon, land use), and the possibility to assign monetary value to ecosystem

services, generating information that is immediately fungible within a traditional economic framework. Nevertheless, this approach has the disadvantage to address only partially the whole issue of biodiversity *per se*.

1.2 Purpose of the project

To address these issues, MEB launched a project aiming at developing a methodology to assess the biodiversity footprint of businesses. Adapted to companies of all sectors, the methodology seeks to adopt the cross-cutting approach specific to ecosystem services while keeping the analysis focused on biodiversity.

The cross-cutting objective of the analysis requires that the biodiversity footprint of an economic operator be expressed using an aggregate indicator. This type of indicator would be decisive in providing businesses with an enhanced understanding of biodiversity and evaluating and guiding action (Di Fonzo M. et al., 2017). Indeed, a single quantitative value provides easily understandable, standardized, cross-cutting and reproducible information. Such information can be tracked over time enabling companies to take stock of their impacts, to refocus their strategy to ensure the effectiveness of measures undertaken and to communicate the findings to various external stakeholders. The outstanding consequences generated by the development of carbon dioxide equivalent metrics in terms of awareness raising and climate change mitigation policies provide a striking example of the catalysing role that a single biodiversity reference indicator could have. These metrics for instance triggered the boom in carbon-based CSR ratings for businesses and carbon audits have now become an important decision-making criterion for a broad category of investors who, either by choice or obligation, are seeking to reduce the carbon footprint of their portfolios. This in turn has a significant impact on the efforts being deployed by the businesses funded. Designing a single aggregate indicator would create a similar momentum for biodiversity.

Devising a summary measure for biodiversity was long believed to be a vain pursuit. Most biodiversity indicators were indeed considered to be suited only to specific assessments, the complexity and threats facing ecosystems varying hugely with the local context. Each context would hence require its own series of *ad hoc* indicators,

(3) <http://www.mission-economie-biodiversite.com/publication>

(4) <http://www.mission-economie-biodiversite.com/gobiodiv>

aggregation leading to coarse approximation rendering results too imprecise to be relevant. This paradigm is now beginning to crumble. Admittedly, specific local features of biodiversity should not be ignored. Yet, the possibility to produce reliable biodiversity summary information is now considered. A number of related initiatives are emerging and - interestingly - propose converging methodological approaches.

Obviously, an aggregate indicator cannot provide a complete measure of biodiversity, nor can it supplant local indicators in factoring in the whole complexity of ecosystems. Yet, such an indicator would provide a global analysis both compatible and complementary to local assessments. Reconciling the micro and macro scales is today's big challenge for biodiversity indicators. This challenge needs to be met if we are to rationalize and tackle biodiversity-related issues on a large scale.

The *Global Biodiversity Score™* (GBS™) attempts to meet this need for an aggregate indicator of a business's biodiversity footprint. The indicator is based on two fundamental pillars: a single quantitative measure and the capacity to factor in businesses' broader scope of activities, more commonly known as the value chain.

With the aim of devising a methodology that factors in the needs and constraints of corporate end-users, CDC Biodiversité has opted for a pragmatic and operational approach by launching the Club of Businesses for Positive Biodiversity (B4B+ Club) which brings together businesses and other stakeholders committed to reach positive biodiversity footprint for their business. This

initiative is designed to get private sector stakeholders on board – mainly companies drawn from all economic sectors – in order to review processes and the practical obstacles involved in deploying the GBS™ methodology under field conditions: links with and value of existing frameworks, access to information, integration into internal decision-making processes, communication and reporting, etc.

The functioning of the Club, illustrated in Figure 1, is the following: CDC Biodiversité produces the methodological content linked to the GBS™. The content is then shared within the working groups to enrich its relevance and to test its operational robustness through case studies. Outputs of the working groups are then delivered to members of the Club during plenary sessions and embedded in practical tools to be used by businesses and financial institutions.

This study, initiated by MEB, is the output of the first year of work of the B4B+ Club. It breaks down as follows: the network of partner initiatives and projects around which the GBS™ methodology has been built are presented in section 2. Next comes a description of the GBS methodology, its objectives and characteristics. The fourth section presents the biodiversity data produced by the Netherlands Environmental Assessment Agency (PBL) using the GLOBIO model since these data are the basis of the GBS™ indicator. The approach used to translate these biodiversity data into GBS™ biodiversity footprint is then explained. Finally, a detailed roadmap of current and future challenges related to the GBS™ indicator is provided.

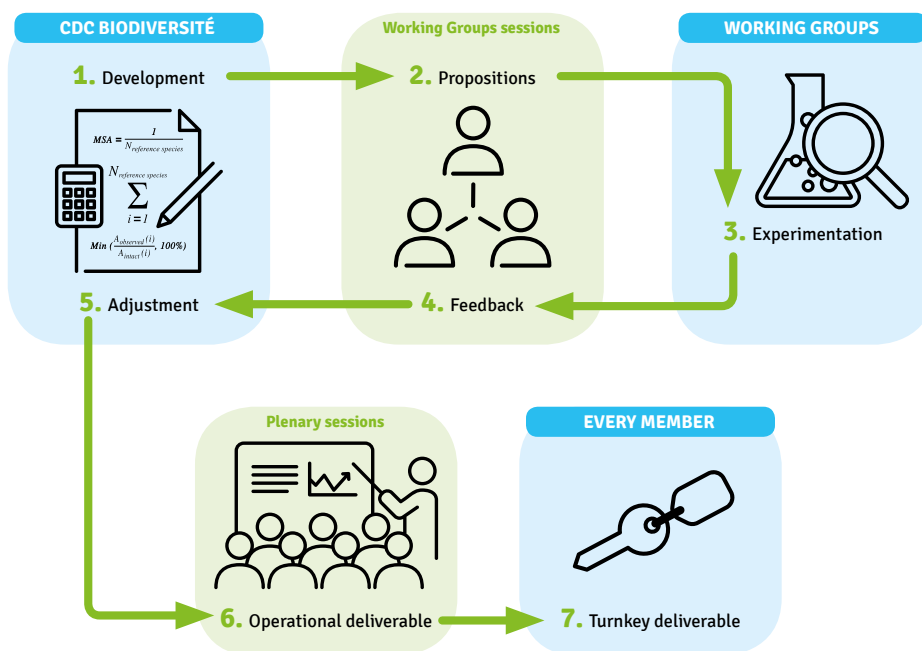


Figure 1: General overview of the interlinkages between the GBS methodology and B4B+ Club

2 Search for complementarity with national and international initiatives on the issue of biodiversity footprint

Work currently in progress on the GBS™ methodology is not and must not be conducted in isolation. Many stakeholders at national and international level have realized the potential of an aggregate quantitative indicator for measuring how a business interacts with biodiversity more effectively. Many stakeholders are working on a number of initiatives and projects in pursuit of this objective. This network of initiatives – of which GBS™ methodology is part – is presented below. In view of the profusion of initiatives in this area, the following overview is not intended to be exhaustive.

2.1 International initiatives

2.1.1 The Natural Capital Coalition (NCC) and the Natural Capital Protocol

The NCC was launched in December 2012 and followed on from The Economics of Ecosystems and Biodiversity (TEEB) for Business and Enterprise. TEEB conducted pioneering research on the economic evaluation of ecosystem services and monetary analysis of externalities for businesses. It provided a first insight into the economic importance of services delivered by ecosystems and the related costs should they disappear. According to a 2008 study (L. Braat, 2008), the wealth loss due to the deterioration of ecosystem services between now and 2050 is estimated at 6% of global GDP (*i.e.*, €12,000 billion).

The NCC took up and expanded the approach of TEEB to include the concept of natural capital defined as “the wide range of benefits that we derive from nature”⁽⁵⁾. More recently, an additional distinction has been introduced between living natural capital (*i.e.*, mainly biodiversity and ecosystems) and non-living natural capital (climate, water and mineral and energy resources). In 2015, NCC launched the Natural Capital Protocol (NCP) with the aim of creating a standardized methodology that would provide a better understanding and quantification of business’s impacts and dependencies on ecosystems. Specific guidelines for different sectors

have been produced: two have been published for the apparel (textiles) and food and beverage sectors⁽⁶⁾ and a third one concerning the financial sector is in the pipeline.

With 250 signatories throughout the world, the NCC is a benchmark initiative for natural capital. It aims to be a cross-cutting initiative bridging missing links between the different communities focused on natural capital (*i.e.*, businesses, public bodies, research labs, associations, etc.) with a view to forging a consensus around best practices. Historically, the NCC has made a lot of progress on the topic of non-living capital and, given the low general awareness of issues related to living capital, a three-year project was launched in 2017 to boost the importance of biodiversity within natural capital.

2.1.2 The EU Commission’s Business@Biodiversity platform

In 2010, the European Union committed to stemming biodiversity loss by 2020 by deploying the strategy underpinned by the CBD’s 20-goal Aichi Targets. Realizing that the initiatives could only succeed by partnering with business, it set up the EU Business@Biodiversity platform to support businesses in understanding, quantifying and reducing their biodiversity impacts. The focus is on promoting and freeing up exchanges between the various stakeholders. With 300 members, it is one of EU’s biggest initiatives.

Work is focused across three separate thematic workstreams⁽⁷⁾, Natural Capital Accounting, Innovation and, more recently, Finance. When the Finance working group was set up in 2016, the need for an aggregate indicator quickly emerged. This type of information is especially relevant for stakeholders in the financial sector who interact with many businesses across a wide variety of sectors and geographies. Consequently, the GBS™ indicator developed by CDC Biodiversité and a similar project⁽⁸⁾ backed by ASN Bank (CREM, PRÉ

(5) <http://naturalcapitalcoalition.org/>

(6) <http://naturalcapitalcoalition.org/protocol/sector-guides/>

(7) <http://ec.europa.eu/environment/biodiversity/business/workstreams/index-en.htm>

(8) ASN Bank has devised a method for measuring the biodiversity footprint of stakeholders in the finance sector and used it to calculate its own footprint in 2016

Consultants, 2016), have been highlighted and have generated interest among stakeholders in the sector. Moreover, as part of NCC's attempts to refocus analyses on biodiversity, the Natural Capital Accounting sub-group is currently compiling a list of biodiversity indicators that could be used by businesses.

2.1.3 The Natural Capital Financial Alliance (NCFA)

The NCFA, formerly known as the Natural Capital Declaration, is an initiative stemming from the finance sector that seeks to mainstream natural capital issues into different financial assets, accounting and reporting frameworks. It is backed up by a Secretariat comprising the UNEP FI (United Nation Environment Programme – Finance Initiative) and the Global Canopy Programme (GCP). With around 40 financial institution signatories, it is a flagship initiative for the financial sector. The NCFA regularly provides operational applications to tackle specific issues: e.g., factoring the risks of deforestation and water- or drought-related risks into the evaluation of bonds⁽⁹⁾. It has been commissioned by the NCC to produce the finance sector guide for the Natural Capital Protocol.

2.1.4 The Business and Biodiversity Offsets Programme (BBOP)

The BBOP is a joint international initiative launched in 2004 by the NGOs Forest Trends and the Wildlife Conservation Society. It aims to devise standards and coordinate a global community of practices around the mitigation hierarchy (*i.e.*, avoidance-reduction-offsetting) for projects being implemented by companies across various sectors (mining, infrastructure, development, etc.). BBOP currently has over 75 members and has succeeded in becoming a reference in this domain, especially for the deployment of offsetting programmes. In 2016, BBOP expanded its brief to seek for ways to achieve net positive biodiversity impact for businesses across all sectors. It now strives to better link mitigation hierarchy practices and methodologies with natural capital accounting more generally through a special focus on biodiversity. CDC Biodiversité has been a member of the BBOP from its creation in 2008 and uses its expertise in offsetting programmes together with its research on the biodiversity footprint of businesses to actively participate in the community's debates.

2.2 French national initiatives

2.2.1 Orée

Orée is a multi-stakeholder association created in 1992 that brings together some 170 businesses, local and regional bodies, professional and environmental associations, and academic and institutional bodies to forge a common approach to best environmental practices and deploy an integrated regional environmental strategy. Its work is structured around three major dedicated working groups: biodiversity and economics, the circular economy and local business ties. Orée is also the French focal point for the CBD's business and biodiversity initiative. The biodiversity and economics working group has tackled the issue of environmental accounting in particular by supporting the thesis of Ciprian Ionescu (Ionescu, 2016) which was used to better structure the beginning of the GBS™ project.

2.2.2 Association française des Entreprises pour l'Environnement (EpE)

EpE, a pro-environment French business think-tank, was created in 1992 and brings together around 40 major French and international groups across all sectors. It helps members to mainstream environmental issues more effectively into both their strategic and operational decision-making processes. Its work focuses on four major themes: climate change, biodiversity, resources and health. EpE is the French partner for the World Business Council for Sustainable Development (WBCSD). After highlighting the need to manage biodiversity more effectively across the value chain, EpE published a report on the related initiatives undertaken by French businesses in this area (EPE, 2016).

(9) <http://www.naturalcapitalfinancealliance.org/>

2.3 Ongoing projects closely related to biodiversity footprint

2.3.1 IUCN USA: creation of a biodiversity-specific return on investment metric

In 2017 the International Union for Conservation of Nature (IUCN), in collaboration with conservation and finance advisors, including CDC Biodiversité, launched a project to design the Biodiversity Return on Investment Metric (BRIM). The metric assesses the change in risk of species extinction caused by investment. The factors that cause species to become threatened (deforestation, hunting, invasive species) can be reduced or mitigated through investment, for instance through the establishment of protected areas. The impacts of the changes in these threats to species extinction risk are calculated for each species in an investment footprint. The importance of the metric is that it can be calculated for any investment anywhere in the world that has species that are globally or nationally threatened and have been evaluated according to the IUCN Red List of Species assessments (currently in excess of 75,000 species). Therefore changes in the metric are comparable between investments across the globe. The draft metric methodology and approach has been developed and a road-testing phase in field conditions is underway. Consolidating the findings obtained using the GBS™ methodology – which uses model biodiversity data at present – by comparing them with the findings of the IUCN project based on actual field data, would be a very worthwhile exercise.

2.3.2 IUCN International: methodology for a national biodiversity audit

In 2017, IUCN launched a project to measure the biodiversity footprint of countries. As for carbon footprint, the idea is to assess the biodiversity footprint of domestic demand including the impact of the trade balance as well as the footprint of national productions and households. For instance, the biodiversity footprint of French products manufactured in China will be allocated to the French biodiversity footprint, while the footprint of exported products will be counted in the footprint of importing countries. As for the previous project, the basis of measurement will draw on the IUCN's Red List of threatened species.

There are powerful synergies with the GBS™ methodology and IUCN plans to use input-output matrix-type analytical tools. This tool together with its anticipated role in the GBS™ methodology will be analyzed in detail in section 6.

2.3.3 Cambridge Institute for Sustainable Leadership/ Kering: biodiversity footprint of raw materials

In 2010, the Kering Group pioneered environmental accounting when it devised an Environmental Profit & Loss account (EP&L) for its Puma subsidiary. In its first version, the methodology included five environmental drivers: water consumption, greenhouse gas emissions, airborne chemical pollutants, area of converted land, and volume of waste. Each of these externalities was audited for each Puma production site and at the different levels of the supply chain. The EP&L helped Puma reduce its environmental impacts and highlight the fact that the most part was caused by supplies, especially raw materials.

In the very first version of the EP&L, biodiversity was factored in on an approximate basis through land use. In 2016, Kering sought to consolidate this analysis and give biodiversity a central role (Becky Chaplin-Kramer, 2016). In partnership with the Cambridge Institute for Sustainable Leadership (CISL), it launched a project to measure the biodiversity footprint of raw materials and the first results were published in May 2017 (Di Fonzo C., 2016). The proposed solutions are very similar to those being advanced by GBS™: use of global model biodiversity data, analysis of production of raw materials, footprint expressed in surface area.

2.3.4 UNEP WCMC / Proteus: towards a global biodiversity footprint for companies from extractive industry

Proteus was launched in 2003 as a joint initiative designed to improve access to and quality of information on biodiversity involving the United Nations Environment Programme-World Conservation Monitoring Center (UNEP-WCMC) and several major groups in the extractive industry. Because of the diversity of locations and activities, the scope of the biodiversity data is global. Proteus helped enhance IUCN's IBAT mapping tool (Integrated Biodiversity Assessment Tool) and standardize the World Database on Protected Areas.

Proteus research help its members to develop expertise in biodiversity using diagnostic assessment and deployment tools tailored to analysis at production and extraction site level. At present, its focus is shifting to a more

global approach to provide an analytical overview of biodiversity issues at site or group level, thus requiring the analysis to be extended either up or down the value chain. Consequently, the whole concept of aggregate indicators has been identified by the sector as essential and the last Proteus meetings brought together experts on the topic, including CDC Biodiversité.

2.3.5 I Care & Consult: incorporating biodiversity into product life cycle analysis

Focusing on the entire value chain is essential to get a global vision of a company's business, *i.e.*, on what goes on at the production sites and in all the related upstream and downstream activities. This holistic approach is more commonly known as Life Cycle Analysis (LCA) and may be applied to many entities, the company, its products, countries or individuals. LCA factors in biodiversity in a partial manner. The main drawbacks of quantitative biodiversity data is the shortage of exhaustive data on species studied and the absence of spatialization. Consequently, land-use data are generally used to approximate impacts on biodiversity. In a joint study for SCORE LCA (SCORE Life Cycle Analysis), an association set up in March 2012 to forge links between

industrial, institutional and scientific stakeholders in order to promote global environmental quantification methods (especially LCA), I Care & Consult and EVEA⁽¹⁰⁾ proposed a roadmap for integrating biodiversity into LCA (CDC Biodiversité, 2015) (I Care, EVEA, 2014). It forms the basis of a project launched by I Care & Consult in 2016, funded as part of the French Government Investment Programme (*PIA*), and aimed at measuring a Product's Biodiversity Footprint (PBF). It is co-funded by three partners – Oréal, Avril and Kering – who wish to help build the PBF metric and test it on one of their own products. Technical developments are handled by I Care and Sayari Environmental Metrics.

As is the case with GBS™, integrating biodiversity into LCA requires global, quantitative and spatialized biodiversity data. This common challenge has led the two projects to work together on their respective development phases. The planned LCA approach uses data from the Local Biodiversity Intactness Index (LBII). This is developed in more detail in the following section and presents broad similarities with the data used for GBS™ methodology.

(10) Research firm specialised in LCA: <http://www.evea-conseil.com/fr/fr/conseil/analyse-du-cycle-de-vie>



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3 Global Biodiversity

Score: objectives, required characteristics and general presentation

3.1 Desired features of the GBS™

With the aim of rounding out the initiatives presented previously and in order to cater to end-user needs as effectively as possible, GBS™ must:

- **be quantitative:** because businesses cannot manage what they do not measure. Up to now, biodiversity has mainly been gauged in an ecosystem services framework, sometimes in a quantitative manner, but with distinct metrics depending on the services considered. At present, the only way to conduct a global assessment or rank issues using a common metric is to employ a monetary value. While such an analysis can provide several pointers it will always be incomplete as it is not underpinned by an intrinsically ecological rationale,
- **cover the entire value chain:** as shown by the example of Puma biodiversity related externalities can be concentrated in the upstream or downstream part of the value chain. Therefore, it is important that the scope of the footprint covers as large a base as possible. This will help involve all economic sectors and not just those with a direct and visible impact, thus covering a much wider range of private sector externalities.
- **be concise:** concise, summary information for the whole company is a boom for communication both in-house and out-of-house with the various stakeholders, *i.e.*, customers, consumers, investors, public authorities, etc.
- **be focused on biodiversity itself:** the aim is to round out the intrinsically incomplete ecosystem services approach when addressing biodiversity. Indeed, listing all the services currently provided by nature and anticipate future ones is impossible. On the contrary, preserving biodiversity maintains current services and ensure their provision in the future. This assurance is twofold as preserving biodiversity makes it possible both to secure the future of current services by maximising ecosystem resilience, and contains an “option” on services that have yet to be discovered or used. Moreover,

relying on a biophysical analysis as well as information based on monetary quantification ensures ecological rationality and avoids situations where economic trade-offs would not favour ecologically coherent solutions. Assessments based on ecosystem services are also unsatisfying to conduct global comparisons of scenarios where given services may be preserved to the detriment of others. Finally, and more fundamentally, biodiversity should not be limited to the services it provides.

- **be responsive to changes:** it must be able to reflect changes operated by end users. For example, if a company rolls out a pro-biodiversity initiative, the indicator in question must be able to detect this change over a timeframe consistent with the business management timeframe.
- **be consensual:** consensus is essential for the type of uses planned. A sufficiently broad consensus is needed if the information is to be relevant and solid enough to deflect criticism. The keys to building this consensus are:
 - biodiversity data validated by the scientific community,
 - a community forged around the methodology and including all categories of stakeholders: *i.e.*, researchers, public authorities, NGOs and businesses,
 - complete transparency thanks to open access working methods.
- **complement and be compatible with local indicators:** the planned methodology does not claim to be a panacea to analyse all links between economic activities and biodiversity. There are already a plethora of tools and indicators suited to local analyses. In the case of environmental impact assessments, these include certifications or processes for validating project implementation. Each of these tools caters to some specific local feature and is therefore the most appropriate in that particular case. It is thus necessary to maintain a strong degree of compatibility with such tools to be able to leverage the vast reservoir of existing available information and lose as little of it as possible when switching to a macro-economic perspective.

3.2 Desired specifications for biodiversity input data used for the GBS™ methodology

The specifications laid down for the GBS™ described previously require that the biodiversity input data used be **quantitative, global, consensual, transparent, and expressed as a single, comprehensible and easily communicable metric**.

In addition, to boost the methodology's ecological credentials, the data must also:

- **reflect the declining abundance** of species. Indeed, focusing only on species extinction risk has shortcomings. First, the risk is difficult to estimate and whether a species has become completely extinct can be complicated to assess. Second, this indicator may tend to underestimate the decline of a species (Gerardo Ceballos, 2017). For example, if the population of a very common bird such as the sparrow declines sharply while remaining within sustainability thresholds the extinction risk does not increase even though there is a huge impact on the population dynamic.
- **factor in ordinary biodiversity** and not just remarkable biodiversity. Data should include information on both the decline in the populations of orangutans in Borneo and sparrows in France as both play key roles in the functioning of ecosystems. However, introducing an optional weighting system based on the remarkability or vulnerability of certain species may be worthwhile for specific analyses.
- **incorporate a quantitative link between drivers and impacts on biodiversity**. Biodiversity data must establish a clear and intrinsic quantitative link with one or several drivers of biodiversity loss and their impacts. Once economic activities broken down into their respective contribution to the various drivers, the pressure – impact relationship provides individual impacts that are aggregated to compute the global biodiversity footprint. Referring to environmental drivers allows a dynamic management of the company's footprint since changes in the contribution to different drivers may be observed in a short time period, and thus reflected by a change in the footprint.

Biodiversity input data should be quantitative, global, consensual, transparent and expressed as a single, comprehensible and easily communicable metric

3.3 Overview of existing data complying with specifications laid down

The following list of datasets is not exhaustive and focuses on data complying with the specifications described previously.

3.3.1 LCA databases

Life Cycle Analysis will be presented in more detail in section 6. This section deals with the biodiversity data used in this tool.

LCA biodiversity data is expressed with the PDF (Potentially Disappeared Fraction) indicator. This metric is based on ecotoxicology models used to measure the health and environmental risks posed by the commercialization of chemicals and drugs. The potential environmental toxicity of a substance is expressed as a fraction of the species that potentially disappears when the substance is introduced into a given environment (*i.e.*, the atmosphere, or the aquatic or marine environment). Based on experiments conducted in a controlled environment, reference tables have been drawn up showing the toxicity of products on biodiversity expressed as PDF by product quantity. These tables are then used for product certification purposes.

From a very early stage, LCA included ecotoxicology data and the PDF indicator was chosen to assess biodiversity impacts with a purpose of ensuring data uniformity. This enabled LCA developers to expand the scope of the drivers being analysed to those related to ecotoxicity (*i.e.*, land, aquatic, marine), land use, eutrophication, acidification and global warming. At present the main obstacle to factoring biodiversity more effectively into LCA is the fact that these databases are not spatialized.

3.3.2 Local Biodiversity Intactness Index (LBII)

“Projecting Responses of Ecological Diversity in Changing Terrestrial Systems” (PREDICTS) project compiles nearly 3 million observations of some 50,000 species (Hudson et al., 2014). The data comes from scientific research and, thanks to broad taxonomic representativeness, constitutes one of the most complete databases of the planet’s global biodiversity. This database is used to quantify the way land-use types and practices impact biodiversity (Newbold et al, 2015). It constitutes the basis of the Local Biodiversity Intactness Index (LBII ; Purvis, 2016 ; Scholes & Biggs, 2005) designed to estimate the state of species diversity in relation to an initial benchmark. Three criteria are considered: the land-use type, the intensity of this use and the ecoregion under analysis. The latter criterion may be regarded as the most important since ecoregions are highly relevant from an ecological perspective. The results are available at a spatial resolution of 1 km by 1 km and may be aggregated by country or another administrative region. Furthermore, the LBII may also be expressed using the average abundance of a species (*i.e.*, MSA for Mean Species Abundance), or the regional scarcity or the phylogenetic diversity of a species (currently in development).

3.3.3 Ecological Footprint (WWF)

The concept of “Ecological Footprint” was developed by the WWF to measure the area required to sustain a population consumption behaviour and way of life (resource use, waste generated) based around six criteria:

- the area of forests needed to produce timber,
- the area of grazing land needed to provide animal-based products,
- the area of arable land needed to provide agricultural commodities,
- the area of ocean required to produce fish and seafood,
- the area of land needed for housing and infrastructure,
- the area of forest needed to absorb CO₂ emissions produced by the energy consumed.

The corresponding area is deduced from both the average yield of each product in the relevant geographical region and the quantity consumed.

3.3.4 The IUCN Red List

IUCN’s Red List documents the global conservation status of over 85,000 plants and animal species and sub-species, based on a set of clear criteria for assessing their extinction risk. These criteria apply to all species and to all parts of the planet. For numerous species, the Red List also documents the main causes of threats. The most recently updated list (2017) features 86,313 species, of which 24,431 are listed as threatened.

The Red List is the result of a vast concertation and validation process carried out over several years by the IUCN Species Survival Commission. Each species or sub-species is classified in one of the following nine categories: Extinct (EX), Extinct in the wild (EW), Critically endangered (CR), Endangered (EN), Vulnerable (VU), Near threatened (NT), Least concern (LC), Data deficient (DD) and Not evaluated (NE). A species or sub-species is classified in one of three threatened categories *i.e.*, (CR, EN or VU) according to a series of five quantitative criteria based on the different biological factors associated with the extinction risk that form the core of the system: population size, rate of decline, area of geographic distribution, degree of population and distribution fragmentation.

3.3.5 The WWF Living Planet Index (LPI)

The LPI measures the global state of biodiversity based on changes in the populations of numerous vertebrates throughout the planet. The database currently references historic data on the abundance of 18,000 populations covering over 3,600 species of mammals, birds, fish, reptiles and amphibians. The data are compiled from various sources such as scientific articles, online databases or national reports. Using a method developed jointly with the Zoological Society of London (ZSL) and the WWF, historical data are aggregated to produce a series of indicators that reflect the current status of biodiversity. The LPI plays a key role in measuring progress towards the CBD’s objective of reducing the pace of biodiversity loss in 2010: according to the biodiversity indicators used, the objective was not achieved. The degree of data spatialization (*i.e.*, resolution) varies according to the level of aggregation: continent, country, region, biome.

3.3.6 GLOBIO model data

The GLOBIO model was developed by a consortium formed in 2003 consisting of PBL, UNEP GRID-Arendal⁽¹¹⁾ and UNEP-WCMC to calculate the impact of environmental drivers on biodiversity in the past, present and future. It draws on driver-impact links found in scientific research. Unlike previous models, GLOBIO uses spatialized data on various environmental drivers – and not field data on species – as input data to estimate the impact on biodiversity. These drivers are taken mainly from the Integrated Model to Assess the Global Environment (IMAGE) and they include land conversion, fragmentation, encroachment, eutrophication and climate change for terrestrial biodiversity, and wetlands conversion, local and network land-use in catchment of wetlands, hydrological disturbance of wetlands and rivers, land-use in catchment of rivers and eutrophication of lakes for aquatic biodiversity.

GLOBIO produces spatialized results for land, aquatic (freshwater) and marine biodiversity at a resolution of 0.5° by 0.5°, *i.e.*, 50 km by 50 km at the Equator. These are expressed in terms of average abundance of a species (*i.e.*, MSA).

GLOBIO is an operational tool used to support and coordinate global or national public policies and is a key part of studies commissioned by heavyweight

institutions such as the CBD, UNEP Finance Initiative, the FAO, the IMF or the OECD that seek to understand the consequences of future development strategies for biodiversity. More specifically, it is used in the CBD for a more effective understanding of current dynamics and to anticipate the consequences of various public policy scenarios with a view to formulating recommendations for achieving the Aichi Targets (PBL Netherlands Environmental Assessment Agency, 2014). The GLOBIO model has been evaluated by the Intergovernmental science-Policy platform on Biodiversity and Ecosystem Services (IPBES, 2017) the scientific body of the CBD in the biodiversity domain equivalent to the International Panel on Climate Change (IPCC) for climate. This evaluation validates the accuracy of the model and circumscribes its operational framework which is compatible with GBS™ methodology.

3.4 Justification for selecting GLOBIO model data

Table 1 sets out the characteristics of the indicators and related data presented previously.

First, it was decided not to use LCA data for 1) the PDF metric based on extinction risk does not take abundance into account and 2) data are not spatialized. However, LCA data do have a very strong, rapidly evolving information potential, particularly in relation to

(11) GRID-Arendal is a government-funded research centre located in Arendal (Norway). It works with the UNEP on questions relating to environmental data and evaluation and is part of the GRID network that produces consolidated accurate environmental data in support of research and public policy.

Table 1: Summary table of the features of the different biodiversity datasets

Characteristics	GLOBIO	IUCN Red List	LPI WWF	Ecological Footprint	LBII	LCA
Quantitative	X	X	X	X	X	X
Global and spatialized	X	X	X	X	X	
Consensual	X	X	X	X	X	X
Single metric	X		X	X	X	X
Comprehensible for non-experts	X	X	X	X		
Focused on biodiversity itself	X	X	X		X	X
Takes account of abundance	X		X		X	
Ordinary biodiversity	X		X			X
Quantitative link with drivers	X			X	X	X

spatialization. Complementarity with other biodiversity data is envisaged, particularly with a view to incorporating drivers currently absent from the GLOBIO model such as land, aquatic and marine pollution.

The LBII is a rich potential source of input data. This indicator and the related data provide a more solid and comprehensive assessment of the “land use” driver than the GLOBIO model since field data and granularity at the ecoregion level are available. “Land use” is however the only driver considered and it considerably restricts the analysis and introduces *inter alia* a structural bias in favour of high-yield practices. Indeed, high yields imply smaller areas used and therefore less pressure from land use, yet generally accompanied by an increase in other pressures: pollution, climate change, eutrophication, etc. The LBII includes three levels of land-use intensity impacting biodiversity. However, the impacts are only measured locally so that surrounding impacts to global biodiversity – due, for instance, to climate change – are ignored. Consequently, the LBII underestimates the negative impacts related to intensification and is biased towards high-yield solutions. Nevertheless, a hybrid solution consisting in replacing GLOBIO data with LBII data for land-use may be envisaged for both datasets can be expressed in the same units without any loss of resolution. This solution would make it possible to refine field data and tie them to this frequently predominant driver.

The ecological footprint is even more biased towards high-yield solutions than the LBII. As explained, the area required to produce natural resources is solely based on the average yield in the geographical area considered. If the yield increases, the ecological footprint then automatically decreases while the impact of production intensification is ignored. Moreover, the ecological footprint approach does not focus on biodiversity *per se* and is not therefore a suitable methodology for measuring biodiversity footprint.

The IUCN’s Red List and the LPI comprise two relevant sources of information on the current state and trends in global biodiversity. Although the Red List documents the origin of the threats to the species studied, the pressure – impact relationship is not stated clearly enough at this stage to suit the needs of our methodology. Linking economic activities to the threats listed seems difficult. The LPI and the Red List may be used in “Pressure-State-Response”-type environmental impact assessment models, but no global database exists to establish a pressure – response relationship. Research into historical data would be worthwhile here.

It was therefore decided to use GLOBIO model data in the GBS™ methodology for they best fit the specifications laid down. In particular, the data are both



spatialized and quantitative. Besides, the scientific worth of the model is confirmed by its use as part of the CBD and its validation by the IPBES. The open access to the model and the transparency of the data produced contribute to its user-friendliness. The MSA metric, presented in detail hereinafter, displays interesting features. In a nutshell, the MSA measures biodiversity intactness relative to its abundance in undisturbed ecosystems. A 100% ratio indicates an intact ecosystem while damages caused by an increase of pressures bring the MSA progressively to 0% when all originally occurring species are extinct in the ecosystem. The gradual deterioration from a pristine ecosystem to a completely artificialized space is easily understandable for non-experts which is a central requirement for an indicator intended to support internal and external corporate communications with all types of public. Also, MSA complies with ecological specifications as it captures changes in ordinary biodiversity by focusing on species abundance and richness and displays clear pressure – impact relationships. However, GLOBIO data carries weaknesses such as the absence of species-related field data

The challenges related to the availability, reliability and standardization of global biodiversity data are highlighted by the international community (Aichi Target No. 19 specifically addresses this topic). Consequently, numerous initiatives emerged around this issue and are making steady progress. Keeping as much flexibility as possible in terms of the input biodiversity data used is thus key. While GLOBIO data currently seem best suited to the purpose in hand, integrating more robust data fitting the specifications laid down must remain an option when such data become available.

3.5 General overview of GBS

Calculating the biodiversity footprint of a business using the GBS™ methodology requires to create a quantitative causal relationship between economic activities and their impacts on ecosystems. These impacts result from the contribution of business' activities to five pressures driving biodiversity loss and identified by the CBD as: land use, pollution, introduction of exotic invasive species, climate change and overexploitation of resources. A business biodiversity footprint can thus be estimated in a two-step process. First, pressures caused by specific economic activities on biodiversity have to be quantitatively assessed. Then, the impacts of these pressures on ecosystems have to be estimated. This last step relies on the GLOBIO model which is based on pressure-impact relationships. As a result, if the contribution of businesses to specific pressures can be assessed, computing its biodiversity footprint using GLOBIO data is straightforward, bearing in mind that the GLOBIO model does not integrate all CBD pressures on biodiversity.

Regarding the first step, namely linking economic activities to environmental pressures, the challenge is to conduct an analysis across an extended scope known as the business's value chain, defined as all of the processes involved in the activity of a business and traditionally broken down into three sub-groups: upstream, on-site and downstream. Consequently, value chain analysis involves tackling numerous processes and new impacts such as the supply of raw materials, manufacturing processes for processed goods, the logistic (transport, storage, etc.) and product use and recycling (which are not traditionally seen as the direct responsibility of companies). To analyse the value chain, the GBS™ methodology mainly uses two external tools: life cycle analysis (LCA) and matrix-based input-output models. As mentioned above, LCA biodiversity data are not best suited to be used for the GBS™ methodology. However, some parts of the LCA can be used to derive economic activity-pressures relationships : these data comprise the standardized use of materials, resources and energy for sector specific production processes as well as emissions of chemical pollutants at every stage of producing a given product. Similarly, the most comprehensive input-output models provide a breakdown of flows of raw materials between the different economic sectors of different countries. Using a preliminary

The GBS methodology consists in creating bridges between economic activities, pressures on ecosystems, and impacts on biodiversity.

work on the spatialized biodiversity footprint of raw materials derived from the GLOBIO model, it is then possible to obtain business level estimates of impacts on biodiversity along the value chain based on the analysis of raw materials use provided by these tools

In the end, the GBS™ methodology consists in creating bridges using these tools and models between economic activities, pressures on ecosystems, and impacts on biodiversity. Figure 2 depicts such a relationship between these three blocks.

The B4B+ Club's work is structured around two working groups composed by the two main categories of stakeholders viewed as the end users of the GBS methodology: businesses from the main sectors of the economy, and the financial sector.

- **the "value chain" group** works on the impacts on biodiversity through the value chain, with a specific focus on supply-related issues and site level impacts, depending on the sectors considered. Life Cycle Analysis can be used here to assess biodiversity impacts of the inputs, outputs of materials as well as the energy attributable to the functioning of a product or service. The sectors concerned here are quite diverse (agri-food, textiles, property development, transport, infrastructure, etc.).

- **the "finance" group** focuses more specifically on the footprint left by financing and investments and it is developing a sector-based approach for various different categories of financial assets categories.

The sectors most closely concerned here are banking, investment and insurance.

Figure 2 depicts the main interactions between the development of the GBS™ methodology and the work of the B4B+ Club. First, the two main working groups ("finance" and "value chain") act as a catalyst for experimentation and enrichment of the GBS™ technical development with a business perspective. Then, the Club will act as multi-stakeholder platform for sharing practices with regards to the strategies and actions that can be put in place to reduce business and financial institutions' biodiversity footprints.

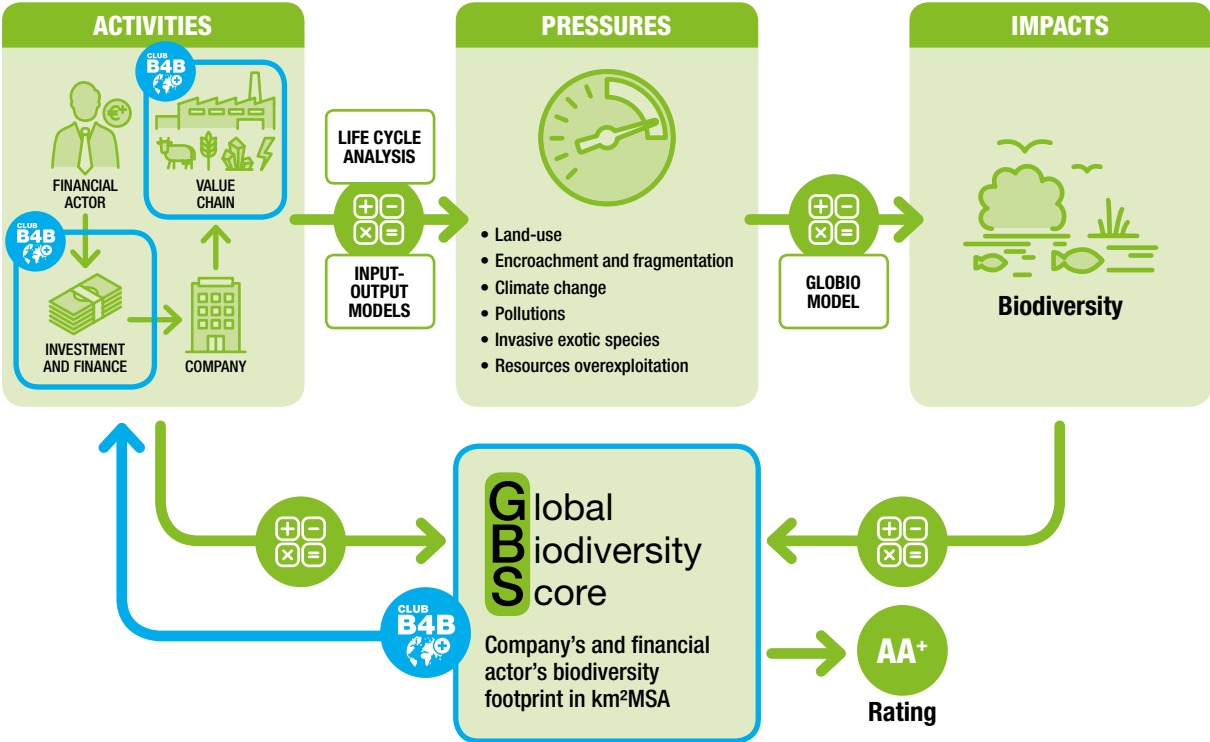


Figure 2: General overview of the interlinkages between the GBS methodology and B4B+ Club





Focus on
biodiversity input
data from the
GLOBIO model
used in the GBS
methodology

4 Focus on biodiversity input data from the GLOBIO model used in the GBS™ methodology

The GBS™ methodology uses input data from the GLOBIO model developed by the consortium consisting of PBL, UNEP GRID-Arendal and UNEP-WCMC. More specifically, the data used was produced as part of a study commissioned by the CBD for the 4th Global Biodiversity Outlook (PBL Netherlands Environmental Assessment Agency, 2014). This section provides a detailed description of the GLOBIO model and the data produced.

4.1 The GLOBIO model's biodiversity indicator: MSA

The Mean Species Abundance (MSA) is the metric used in the GLOBIO model that describes biodiversity changes with reference to the original state of ecosystems. It is defined as the average abundances of originally occurring species relative to their abundance in the undisturbed ecosystem. Therefore, MSA varies between 0% and 100%. The sense of the term “undisturbed ecosystems” and the problem posed in terms of baseline are presented in more detail at a later stage. For now it is considered equivalent to a pristine state, intact and undisturbed by human activity. The MSA is defined as:

$$MSA = \frac{1}{N_{reference\ species}} \sum_{i=1}^{N_{reference\ species}} \text{Min} \left(\frac{A_{observed}(i)}{A_{intact}(i)}, 100\% \right)$$

Where

- MSA* = mean abundance of original species,
- N_{reference species}* = total number of species in an undisturbed ecosystem,
- A_{degraded}(i)* = abundance of species *i* in the observed ecosystem,
- A_{intact}(i)* = abundance of species *i* in an undisturbed ecosystem,

Because the ratios by species are truncated at 1⁽¹²⁾, a species growing to the detriment of others causes the index to decrease. Indeed, in this instance, the ratios of these latter species fall without any corresponding rise

in the ratio of the dominant species. Moreover, exotic species are not included in the calculation of MSA so any growth in their population to the detriment of endemic species will result in a decline in the overall ratio. MSA also reflects homogenization processes. Indeed, a scenario in which a limited number of species thrive in all ecosystems would cause the MSA to fall since only originally occurring species contribute to the MSA. MSA is applicable to both land and aquatic ecosystems.

This study uses MSA (defined by the formula above) and its surface area equivalent, *i.e.*, km²MSA. The latter is the product of MSA multiplied by the area to which it applies (expressed in km²). For example, for a surface area of 1 km² of intensely cultivated fields (MSA = 10 %), the value is 1x10% = 0.1 km²MSA. Similarly, a change in MSA from 100% to 75% for a surface area of 1 km² corresponds to a loss of (100%-75%)*1 = 0.25 km²MSA. Equivalently, a scenario where MSA remains at 100% across 75% of the surface area (0.75 km²) and drops to 0% in the remaining 25% (0.25 km²) would also generate a loss of 0.25 km²MSA, as shown in Figure 3.

These mental gymnastics considering a loss spread over an area and a total loss in a portion of the area as equivalent are key for future interpretations of results expressed in km²MSA. In a way, it allows us to interpret a loss of *x* km²MSA as the conversion of *x* km² of undisturbed ecosystem into a completely artificialized one, with obvious advantages for communication. Nevertheless, we should bear in mind that this interpretation is not strictly accurate with regard to the model since – as pointed out previously – MSA only considers endemic species. Thus, an MSA of 0% could also correspond to an ecosystem populated solely with exotic species.

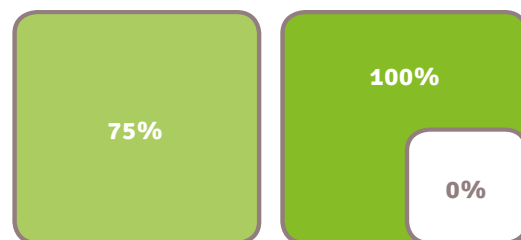


Figure 3: Illustration of the equivalence between a decline in MSA and partial artificialization

(12) Truncation is caused by the “minimum” function in MSA formula

4.2 General overview of the GLOBIO model

GLOBIO is a spatialized model covering the entire surface of the planet. It is divided into 0.5° by 0.5° grid cells (50 km by 50 km at the Equator), that is 720 x 360 = 259,200 grid cells. The model seeks to assess the state of biodiversity intactness in each of these grid cells.

It is built on a set of equations linking environmental drivers and biodiversity impact involving a two-step process: 1) assessing the intensity of accumulated pressure within each grid cell and 2) determining the impact on biodiversity.

The environmental drivers of terrestrial biodiversity change considered are land-use and harvesting, fragmentation of natural areas, atmospheric nitrogen deposition, infrastructure, encroachment on natural areas and climate change. The drivers and expected trends are derived from the IMAGE model⁽¹³⁾ while their relative impacts on biodiversity are assessed within GLOBIO.

Pressure – impact relationships are derived from peer-reviewed literature (nearly 300 articles) using meta-analyses. Data are extracted from relevant articles and MSA values are calculated so that each selected paper provides one or several points in the pressure-impact space specific to the biome (e.g., a temperate forest) and environmental driver (e.g., atmospheric nitrogen deposition) studied. Regression analysis is then performed on the resulting clustered data for each couple pressure-biome to estimate the corresponding pressure - impact relationship.

4.2.1 Review of the environmental drivers impacting biodiversity

A LAND USE

Land-use data is compiled from different sources. The Global Land Cover 2000 (GLC2000) map representing land cover in the year 2000 is used as a starting point. The 23 land cover classes in the GLC2000 are aggregated into broader classes according to their MSA value to fit the 13 land-use classes displayed in GLOBIO. The classes thus reflect the intensity of land-use on cultivated land (including forests) and grazing areas. Intensity is measured based on the research of J. Dixon (Dixon J, 2001) for cultivated areas, data from the IMAGE model for grazing areas, and data provided by the FAO (2001) for forests. Thirteen land-use categories are factored into the GLOBIO model. Three categories refer to natural areas insofar as they are not dedicated to any human activity in particular, *i.e.*, natural forests, natural grasslands, and snow and ice. Ten other categories correspond to: intensive agriculture, extensive agriculture, woody biofuel agriculture, irrigated agriculture, cultivated grazing areas, forestry plantation, harvest forestry, selective logging forestry, reduced impact logging forestry, and urban areas. These ten land-use categories are divided into two sub-categories: **man-made land**, *i.e.*, urban areas and croplands (intensive, low-input, biofuel and irrigation-based) and other land-cover (all other classes).

89 peer-reviewed articles comparing species' abundance between at least one land-use type and primary vegetation were selected. Though tropical forests are overrepresented in this sample, studies from other biomes confirm the general picture. For urban areas no proper data was found and the value of 5% was assigned by expert opinion. The results are summarized in Figure 4.

(13) IMAGE is used by the IPCC to study GHG emission scenarios known as the Representative Concentration Pathways (RCPs). GBS input data are modelled under the "trend" scenario, that is the scenario most compatible with today observable demographic and consumption trends. An illustration of the model is provided in appendix

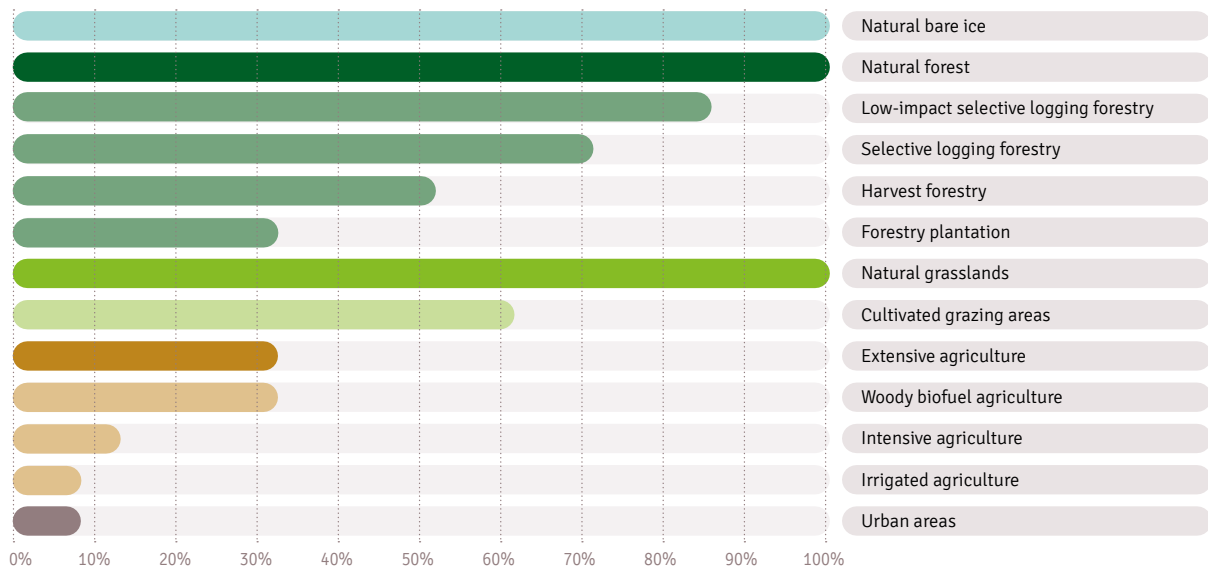


Figure 4: MSA values by land-use type (Alkemade R., 2009)

B FRAGMENTATION OF NATURAL ECOSYSTEMS

Species' population is positively correlated with habitat size. As natural habitats shrink and are more and more fragmented due to human activity the functioning of ecosystems is hampered, causing biodiversity loss.

Natural patch size is measured by reclassifying GLC2000 categories into two sub-categories mentioned in the previous section. Fragmentation is assumed to be caused only by man-made land and infrastructures. To define the habitat fragments, an overlay of the Global Roads Inventory Project (GRIP) infrastructure map and the GLC2000 land-cover map is made. Six datasets on a large sample of species were used to derive the relationship between MSA and patch size. The proportion of species that have a viable population is used as a proxy for MSA (Verboom J., 2007).

C ENCROACHMENT

Human encroachment comprises anthropogenic activities in otherwise natural areas. Direct (noise, pollutions, etc.) and indirect impacts (right of way for hunting, tourism, etc.) are accounted for and an MSA of 70% is applied within a 20-km zone around man-made areas for all types of biomes. The database of peer-reviewed articles on which this rule is based is not available for this driver.

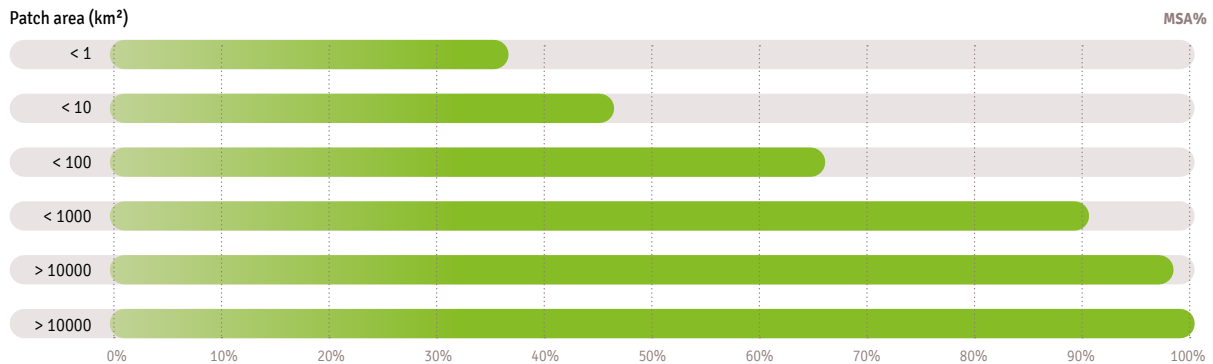


Figure 5: MSA values relative to natural patch size (Alkemade R., 2009)

D INFRASTRUCTURE

As mentioned previously, infrastructure affects MSA both *via* habitat fragmentation and *via* disturbance of the surrounding natural habitat. Direct (noise, pollution, roadsides, etc.) and indirect impacts (*i.e.*, inherent increase in tourism and hunting) are considered. Artificialization is also included in the “land-use” driver.

A global map of linear infrastructure (road, rail, electric lines and pipelines) is compiled using the GRIP datasets and the Digital Chart of the World database (DCW, DMA 1992). Impact zones of different widths varying by biome are calculated using UNEP/RIVM (2004) metho-

dology. 74 studies were used to determine the impacts of infrastructure on species abundance. Studied species groups include birds, mammals, insects, and plants. Some authors studied direct effects of roads and road construction by measuring the abundance of species near roads and on larger distances from roads. Other authors studied indirect effects like the increase of hunting and tourism occurring after road construction. The results for each biome, including direct and indirect effects, are summarized in Figure 6 and Figure 7.

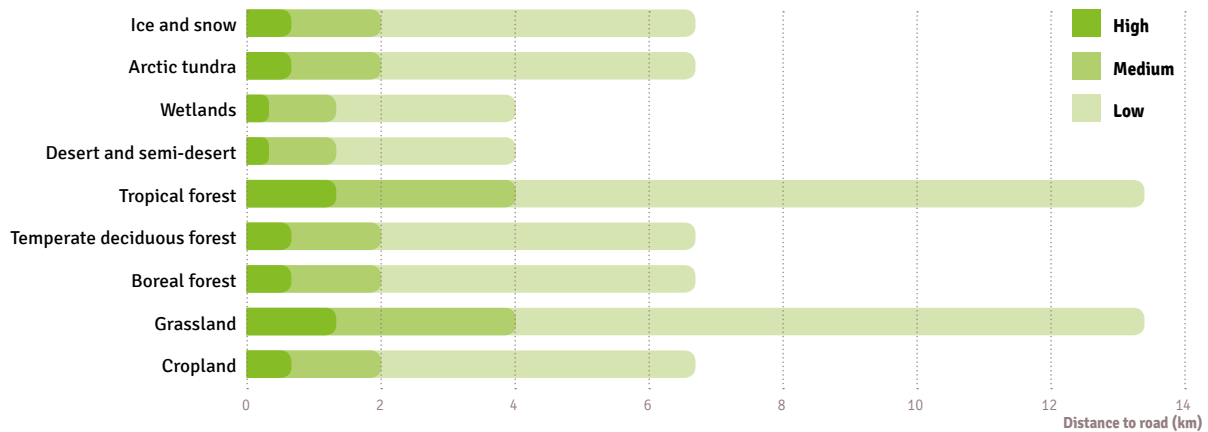


Figure 6: Infrastructure impact buffer zones by biome (Alkemada R., 2009)

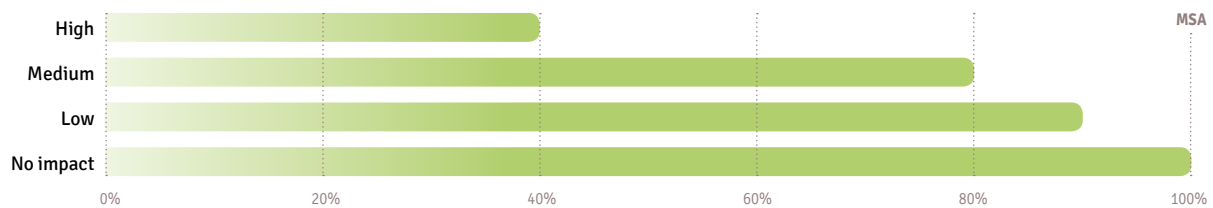


Figure 7: Impact buffer zones and corresponding MSA values (Alkemada R., 2009)

E ATMOSPHERIC NITROGEN DEPOSITION IN NATURAL ECOSYSTEMS

Adverse effects of nitrogen deposition are observed when nitrogen deposition in ecosystems (e.g. from croplands fertilization) exceeds their assimilative capacity, referred to as critical load. Nitrogen deposition in exceedance of the critical load is airborne into natural habitats leading to eutrophication and acidification of ecosystems. In such cases, species that are better adapted to these conditions become more competitive and may proliferate to the detriment of others.

The IMAGE model simulates nitrogen deposits based on agriculture and livestock production data (PBL Netherlands Environmental Assessment Agency, 2006). Moreover, a map of critical nitrogen loads for the main ecosystems is drawn up based on a map of the Earth's different soils and the sensitivity of ecosystems to added nitrogen (Bouwman AF, Van Vuuren DP., 2002). 22 papers on the experimental addition of nitrogen to natural systems and its effects on species richness and species diversity were selected. Pressure-impact relationships were established between the yearly amount of added nitrogen in exceedance of the critical-load and the relative local species richness (considered as

a proxy for MSA). The experimental addition of nitrogen is assumed to have effects that are similar to atmospheric deposition. Outcomes by type of biome are shown in Figure 8.

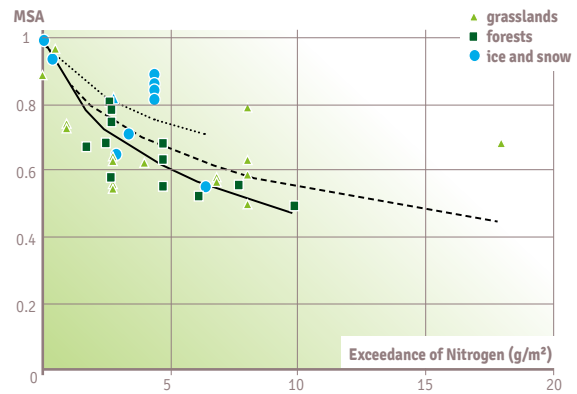


Figure 8: Regression values for MSA for nitrogen exceedance (Alkemade R., 2009)



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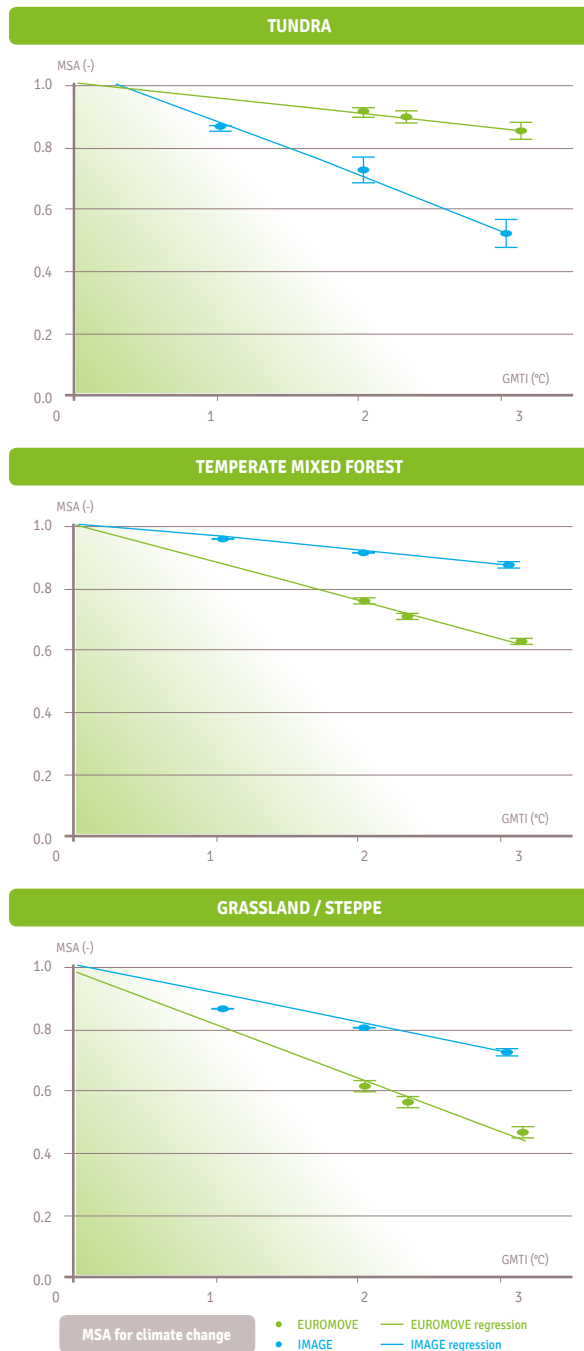


Figure 9: MSA values and regression analysis for different biomes. Source : www.globio.info/what-is-globio/science-behind-globio/climate-change

F CLIMATE CHANGE

Climate change causes shifts in the geographic distribution of biomes and species for those unable to adapt to future climate are threatened. The pressure is included in GLOBIO using the Global Mean Temperature Increase (GMTI, in °C) as simulated with the IMAGE model.

The approach used to assess the impact of climate change is different from those used for other drivers. Field data on this topic are hard to compile hence the use of modelled data. Two methods are employed to derive the pressure - impact relationship. The first one relies on the EUROMOVE model (Bakkenes M. A. J., 2002) that estimates species shifts between 1995 and 2050 under three different climate change scenarios. For each grid cell the proportion of remaining species is calculated (Bakkenes M. E. B., 2006) and, for each biome, a linear regression equation is estimated between this proportion and the GMTI. In the second model, the expected stable area for each biome is calculated based on the work of Leemans and Eickhout (Leemans R., 2004) presenting percentages of stable areas of biomes at 1, 2, 3, and 4°C GMTI. The regression lines predicting the smallest effects are selected for each biome, yielding conservative estimates. The proportion of remaining species or stable areas are considered proxies for MSA. The graphs of Figure 9 show the regression-equation lines for three biomes.

G CALCULATION OF TOTAL MSA

When calculating total MSA for a given area, two situations arise:

- Man-made areas are assumed to be “land-use dominant” in the GLOBIO model, land-use being thus the only driver impacting biodiversity in these areas, therefore

$$MSA_{total} = MSA_{Land\ use}$$

- for all other land uses, the impacts of the various drivers are assumed to be additive and

$$MSA_{Total} = MSA_{Land\ use} \times MSA_{Fragmentation} \times MSA_{Encroachment} \times MSA_{Nitrogen\ Deposition} \times MSA_{Infrastructures} \times MSA_{Climate\ Change}$$

4.2.2 Data produced

The data produced are worldwide spatialized data. The spatial resolution is 0.5° by 0.5°. Biodiversity intactness related to individual drivers expressed in MSA is available for each grid cell and global biodiversity intactness is calculated by multiplying the MSAs for each driver. This reflects the cumulative aspect of the different pressure factors. The resulting global MSA map is presented in Figure 10 for the years 2000 and 2050 while the average biodiversity loss associated to each driver for 2010 and 2050 is in Table 2.

Table 2: Average MSA loss in % and km ² MSA in 2010 and 2050 by driver						
Driver	Biodiversity loss in 2010		Biodiversity loss in 2050		Biodiversity erosion 2010-2050	
	km ² MSA	MSA	km ² MSA	MSA	km ² MSA	MSA
Land-use	24 512 161	18.9%	28 906 375	22.2%	-4 394 214	-3.4%
Infrastructure	2 806 672	2.2%	4 827 905	3.7%	-2 021 233	-1.6%
Encroachment	6 507 580	5.0%	5 826 072	4.5%	681 508	0.5%
Fragmentation	2 422 955	1.9%	2 211 380	1.7%	211 576	0.2%
Eutrophication	808 564	0.6%	968 858	0.7%	-160 293	-0.1%
Climate change	4 756 026	3.7%	10 800 818	8.3%	-6 044 792	-4.6%
Total	41 813 959	32.2%	53 541 408	41.2%	-11 727 449	-9.0%

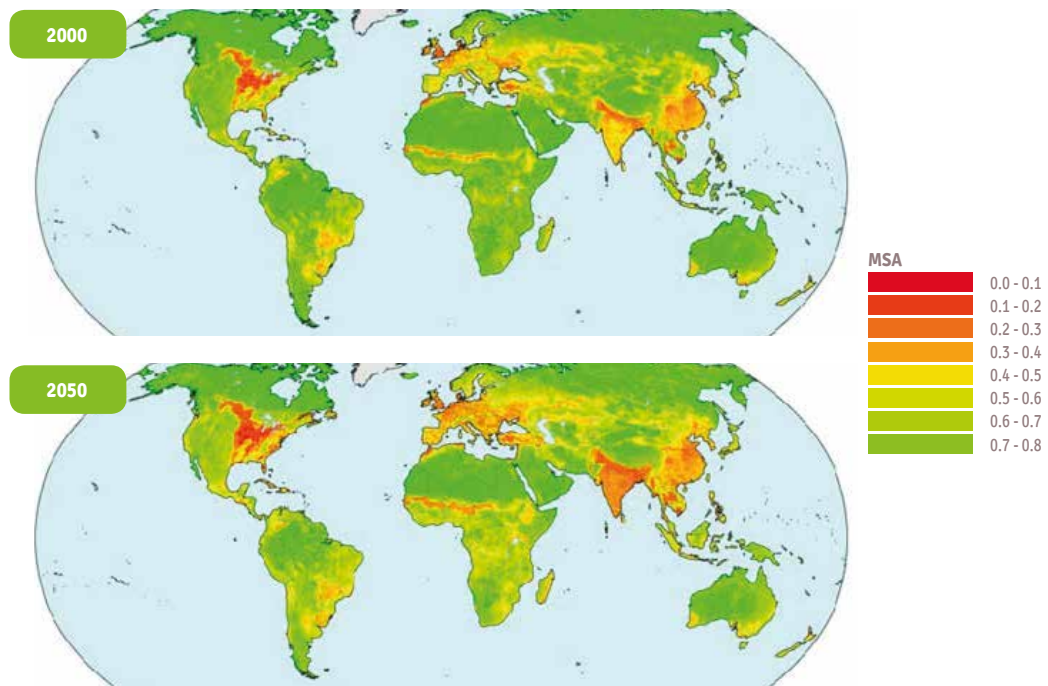


Figure 10: Combined relative MSA using all pressure factors for years 2000 and 2050. (Alkemada R., 2009)

An aerial photograph of a winding river flowing through a lush green landscape. The river is dark and meanders through fields and forests. A concrete bridge with several piers crosses the river in the lower-left quadrant. A road runs parallel to the river on the right side. The overall scene is vibrant and natural.

GBS™ methodology:
first step on
the biodiversity
footprint of raw
materials

5 GBS™ methodology: first step on the biodiversity footprint of raw materials

As explained in section 3.5, computing a business's biodiversity footprint requires to link its economic activities to impacts on biodiversity. The impact of various environmental drivers on biodiversity is provided by the GLOBIO model so that the next step consists in calculating the contribution of economic activities to each driver. GBS™ methodology thus starts with estimating the biodiversity footprint of raw materials including agricultural commodities, wood, minerals, energy, etc. The overriding principle here is to calculate the contribution of raw materials production processes to drivers in order to deduce a footprint per quantity produced. A "footprint database" for all raw materials and by country is then gradually compiled.

5.1 Input biodiversity data used

GBS™ methodology uses the predicted annual biodiversity change as main input data so that the dataset is:

$$GBS\ data_{input} = \frac{1}{40} (GLOBIO\ data_{2050} - GLOBIO\ data_{2010})$$

Where differences between GLOBIO modelled biodiversity data in 2010 and 2050 are annualized. Focusing on annual biodiversity variations has several benefits:

- it is consistent with the framework recommended by the PBL. The strength of the model indeed lies in its predictive capability so that predicted biodiversity variations and the potential causes matter more than the absolute state of biodiversity intactness in 2010 and 2050. This framework is also of particular interest considering the international community's objective of stemming biodiversity loss while no exact target levels are recommended,
- it minimizes the issue of the "reference" or baseline ecosystem. The definition of reference ecosystems in the PBL model is quite vague, referring to "undisturbed" and "intact" ecosystem whereas the notion of intactness makes no sense from an ecological perspective. Human influence has indeed existed for

thousands of years and has become inseparable from some ecosystems while intactness is a moving concept considering the intrinsic dynamic of the living world. Moreover, reference ecosystems are specific to each scientific paper included in the meta-analyses which makes the idea of a unique reference ecosystem a void concept in this context,

- it is well-suited to the current economic environment where the year is the main time period considered. There is thus a good fit between biodiversity annual variations and the bulk of economic data. This is also consistent with production cycles for agricultural raw materials.

5.2 The reallocation of impacts to economic sectors

5.2.1 Description of general principle

The principle is the same for each raw material and consists in determining the contribution of production processes to each of the five environmental drivers: land conversion, fragmentation, encroachment, eutrophication of natural areas and climate change. For the sake of clarity, the example of intensive wheat farming in a field of 1,000 m² in a temperate region illustrates the approach involved (cf Figure 11).

The drivers may be grouped into three categories, each requiring specific reallocation processes:

- **spatial drivers:** they result either directly or indirectly from the land-use required to produce raw materials and encompass land conversion, fragmentation and encroachment,
- **local-impact emissions drivers:** they result from emissions caused by the production of raw materials impacting local biodiversity and encompass atmospheric nitrogen deposition,
- **global-impact emissions drivers:** they result from emissions caused by the production of raw materials impacting global biodiversity, in this case greenhouse gas emissions and the engendered climate change.

5.2.2 Spatial drivers

We need to bear in mind that since the focus here is on annual biodiversity variations, only land conversion is considered. As regards the wheat field, the question is whether it will expand, remain stable or contract during the current year. Only a change in its surface area will generate a spatially-driven footprint. In theory, a change in the geography of the field not impacting its surface area could drive a change in the footprint related to fragmentation and encroachment onto surrounding natural areas. However, the model does not provide this degree of refinement and these impacts are ignored.

A DIRECT-IMPACT SPATIAL DRIVERS: LAND CONVERSION

The reallocation process used for land conversion is relatively simple. It requires that areas depicting land-use change be identified and the corresponding MSA impacts be allocated to the new land-use type according to the following formula:

$$\Delta MSA_{conversion} = (MSA_{New} - MSA_{Old}) \times Surface$$

For example, if the wheat field expands by 10% from 1,000 m² to 1,100 m² into equally permanent grassland and natural forest, the conversion outcome is negative. Indeed, the biodiversity of the intensively-farmed field

(MSA=10%, see Figure 4) is poorer than that of the permanent grassland (MSA=70%, see Figure 4) and the natural forest (MSA=100%, see Figure 4). The biodiversity loss therefore equals to:

$$MSA_{conv}(Wheat\ field) = (10\% - 70\%) \times 50 + (10\% - 100\%) \times 50 = -75m^2$$

NB: if on the other hand, the surface area of the field had diminished to the benefit of the natural forest, the conversion outcome would have been positive, reflecting a biodiversity gain.

B INDIRECT-IMPACT SPATIAL DRIVERS: FRAGMENTATION AND ENCROACHMENT

Because these drivers only impact surrounding natural areas, the allocation process is different. Natural areas are taken as starting points instead of raw material production sites. The principle used for fragmentation is identical to that used for encroachment albeit a little more complex as infrastructure must be factored in.

The two causes of fragmentation in the model are man-made lands and infrastructures. Theoretically, disentangling the individual impact of each is complex. For example, if a natural forest is surrounded by fields and crossed by a road, what proportion of fragmentation is due to the fields? What proportion is due to the road? Should we count all fields in the same manner? Because no solution is completely accurate, the trade-off between infrastructure and man-made lands

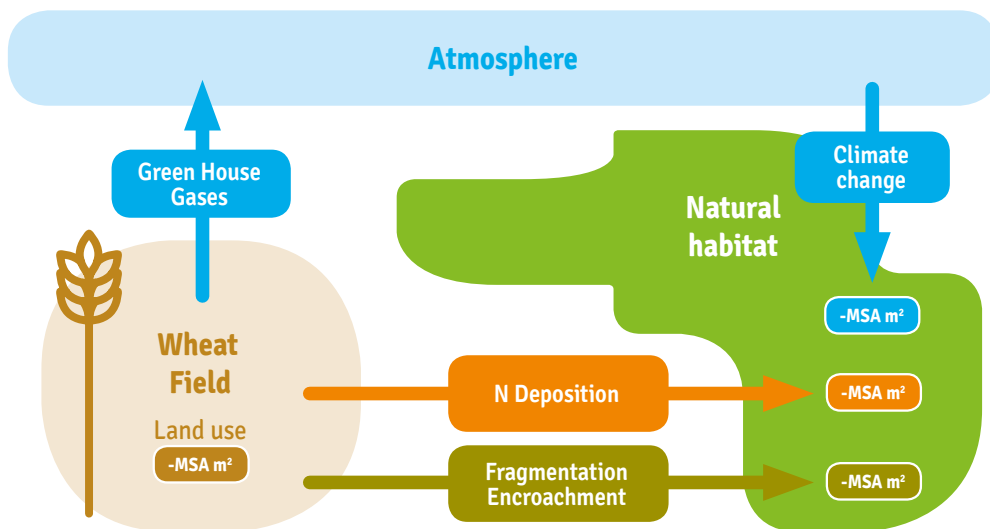


Figure 11: Reallocation process for wheat production

is deliberately simple. Impacts due to fragmentation are allocated based on the land use surrounding the natural area. The allocation rule is the following:

- presence of man-made lands without infrastructure: 100% of the fragmentation impact is allocated to man-made lands,
- presence of infrastructure without man-made lands: 100% of the fragmentation impact is allocated to infrastructure,
- presence of man-made lands and infrastructure: 50% of the fragmentation is allocated to man-made lands and 50% to infrastructure.

In the wheat field example, only the natural forest is considered, for it is the only nearby natural area. Its surface is anticipated to decrease from 10,000 m² to 9,500 m² and the biodiversity loss due to fragmentation increases

from $MSA_{frag\ old} = 15\%$ to $MSA_{frag\ new} = 17\%$.

Encroachment remains unchanged. The fragmentation outcome for the forest is:

$$\begin{aligned}\Delta MSA_{frag}(Forest) &= MSA_{frag\ old} \times S_{old} - MSA_{frag\ new} \times S_{new}, \\ \Delta MSA_{frag}(Forest) &= 15\% \times 10000 - 17\% \times 9500 = -115 \text{ m}^2 \text{MSA}.\end{aligned}$$

Fragmentation is thus anticipated to cause a biodiversity loss equal to -115 m²MSA.

Note that the same MSA loss due to fragmentation could have led to a positive fragmentation outcome if the final surface area had been greatly reduced. If the forest had shrunk by half, the outcome would have been:

$$\Delta MSA_{frag} = 15\% \times 10000 - 17\% \times 5000 = 750 \text{ m}^2 \text{MSA}.$$

This result may be surprising at first glance. Yet considering all the spatial drivers, it is likely that this positive biodiversity impact would be offset by the negative impacts due to land conversion. This mechanism should however be kept in mind for the subsequent interpretation of the results.

Back to the wheat field example. Fragmentation biodiversity losses previously calculated can be allocated to the surrounding areas. The forest grid cell also contains a road, the wheat field and another 500 m² field. Because infrastructure is present, 50% of the loss is allocated to it, i.e., -57.5 m². The remaining 50% are allocated to the two fields in proportion to their respective areas. Consequently, the contribution of the wheat field which area is 900 m² at year-end is

$$MSA_{frag}(Wheat\ field) = -57.5 \times \frac{900}{900 + 500} \approx -37 \text{ m}^2 \text{MSA}.$$

5.2.3 Local-impact emissions drivers

At this stage of the methodology's development, the only driver of this type is airborne nitrogen compounds associated to agricultural commodities production and causing eutrophication of natural areas. However, the allocation principle could be applied to all similar pollution types. As for direct-impact spatial drivers we start from the natural areas impacted. This time, the impact is allocated to surrounding areas in proportion to the nitrogen compound emissions they generate.

Mapping the nitrogen compound emissions requires some preliminary work on the Emissions Database for Global Atmospheric Research (EDGAR). This spatialized database stems from a joint initiative between the European Commission (DG Joint Research Centre) and the PBL. It maps past and present human greenhouse gases and atmospheric pollutants emissions on a global scale. The emissions are calculated from the sector-based activities declared by countries and their related emissions factors (Olivier J, s.d.). Data are available either by economic sector or by country in the form of spatial grid cells with a resolution of 0.1° by 0.1°.

The nitrogen emissions generated by agriculture documented in EDGAR database are allocated to the corresponding GLOBIO grid cells. This work is needed to match EDGAR and GLC2000 data resolutions and to ensure consistency between land-use and observed emissions, so that all agricultural sector emissions are allocated to cells in which the agricultural surface area is not null.

Once this has been done, allocating the impact of eutrophication of a natural area to surrounding areas is straightforward. The surrounding area is extended outwards in a concentric manner until nitrogen compound emissions are detected. Once they are identified, the "emitter" areas are credited with the proportion of their impact in the area's total emissions.

Back to the wheat field example. As for fragmentation, only the natural forest – the only nearby natural area – is considered. According to GLOBIO, its area declines from 10,000 m² to 9,500 m² for the current year and the biodiversity loss due to atmospheric nitrogen deposition changes from $MSA_{eutro\ old} = 1\%$ to $MSA_{eutro\ new} = 1.5\%$.

For this forest, the eutrophication outcome is

$$\begin{aligned}\Delta MSA_{eutro}(Forest) &= MSA_{eutro\ old} \times S_{old} - MSA_{eutro\ new} \times S_{new}, \\ \Delta MSA_{eutro}(Forest) &= 1\% \times 10000 - 1.5\% \times 9500 = -42.5 \text{ m}^2 \text{MSA}.\end{aligned}$$

The eutrophication outcome is -42.5 m² MSA.

The area surrounding the forest counts a wheat field, another field and a factory with annual emissions of respectively 3, 2 and 10 tonnes of nitrogen equivalent (Neq). The contribution of the wheat field to eutrophication of the forest is calculated as follows

$$\Delta MSA_{eutro}(Wheat\ field) = -42.5 \times \frac{3}{3+2+10} \approx -8.5 \text{ m}^2 \text{MSA}.$$

5.2.4 Global-impact emissions drivers

In principle, this case only concerns climate change. Here, the approach is not based on mapping. Because local emissions have a global effect, the emission site does not matter. The objective is to come up with results on a national scale so that higher resolution of emissions is not necessary. For the agricultural sector, we use the FAO's data on national greenhouse gas emissions, the most detailed and reliable available for the sector. These distinguish between ten types of emissions: enteric fermentation, manure management (aerobic and anaerobic decomposition of excrement), rice cultivation, synthetic nitrogen fertilisers, manure applied to soils, manure left on pasture, crop residues (nitrification), burning crop residues, burning grassland, and energy used (including for fishing). For other economic sectors, the EDGAR database is used.

In its most recent report, the IPCC develops the concept of a "carbon budget" that must not be consumed if we are to achieve the objective of +2°C. Ensuring a proba-

bility of meeting this goal greater than 66% requires that cumulative anthropogenic carbon emissions since the beginning of the industrial era (1750) through to a far-off indeterminate future do not exceed 1000 PgC, *i.e.*, 3,666,667 megatons of equivalent. The IPCC estimates that, of these 1000 PgC, 555 PgC had already been consumed at the end of 2011. Keeping within this budget corresponds to emissions trajectory RCP2.6 used by the PBL to produce GBS input data.

The contribution of a given GHG emission to total biodiversity loss due to climate change is measured in terms of its contribution to the global budget defined by the IPCC. Here, the total loss considered is evaluated by the GLOBIO model from the beginning of the industrial era (1750) through to 2050. The year 2050 has been chosen because this is the timeframe laid down by the international community to stop biodiversity loss.

For example, the calculation related to the emission of a megaton (Mt) of CO₂ equivalent is as follows. According to the PBL model, the global MSA loss due to climate change is 5.6% in 2050 under RCP 2.6 (see Figure 12).

THE SPECIFIC CASE OF CLIMATE CHANGE

Climate change is the consequence of greenhouse gas (GHG) emissions since the beginning of the industrial era. The lifespan of GHGs in the atmosphere varies from around 10 years for methane to several thousand years for certain halocarbons. Therefore, present climate change is the result of current and past emissions as well, causing an **inertia effect of past emissions**. Calculating the individual contribution of a given GHG emission to biodiversity loss due to climate change is thus a complicated task. Strictly speaking, the contribution of an emission should be included not only for the year in progress but for its entire lifespan in the atmosphere. This raises a uniformity issue since only the annual impacts are considered for the other drivers. **Assuming that present and future losses can be aggregated, the question then becomes: Which impact time period should be considered?** Factoring in the entire lifespan of a GHG emission is not an option since it requires to forecast biodiversity trends over timeframes spanning way beyond temporal limits of the models. Picking an end date and focusing on the biodiversity loss through that date implies a mechanically decreasing impact of emissions since those emitted in the first years stay longer in the atmosphere. The solution of a rolling window over a fixed period – say the next 20 years – is neither satisfactory as the size of the window impacts widely the results. Lastly, global warming is the consequence of a series of aggregated emissions above the Earth's absorption capabilities. In this context, focusing on individual emissions seems irrelevant. This brings us back to the issue of the legacy of past emissions. Consequently, the quest for a "scientifically accurate" solution to calculating the contribution of a given GHG emission to annual biodiversity loss has been abandoned. Instead, **an approach based on shared responsibility for climate global commons based around the work of the IPCC has been adopted.**

Applying this to the Earth's total land surfaces, *i.e.*, 130 000 000 km², corresponds to a loss of 7,280,000 km²MSA. Given that the total carbon budget fixed by the IPCC is , the contribution of a megaton of CO₂ is

$$\frac{1}{3666667} \times 7280000 = 1.98 \text{ km}^2 \text{MSA}$$

This approach is illustrated in Figure 12.

This allocation rule has several benefits:

- it avoids the physical unit issue that can only be resolved by resorting to strong hypothetical trade-offs,
- it puts past, present and future emissions on an equal footing,
- it factors in the cumulative nature of the impacts of a carbon emission over time.

Let's finish up with the wheat field example. Although climate change is calculated on a national basis, the approach explained is applicable to any emission. In the case of the wheat field, if agricultural activity over the year generated the emission of 0.5 tonnes of CO₂ equivalent, the climate change footprint is calculated as:

$$MSA_{clim}(Wheat\ field) = \frac{0.5}{3.67 \cdot 10^{12}} \times 7.28 \cdot 10^{12} \approx 1 \text{ m}^2 \text{MSA}$$

5.2.5 Overall outcome of the wheat field case study

The total impact of the wheat field for the year in progress is

$$MSA_{tot} = MSA_{conv} + MSA_{frag} + MSA_{encroach} + MSA_{eutro} + MSA_{clim},$$

$$MSA_{tot} = 115 + 37 + 0 + 8.5 + 1 = 161.5 \text{ m}^2 \text{MSA}.$$

The average annual yield of the field is 3t/ha, *i.e.*, annual output of $3 \times \frac{1100}{10000} = 0.33 \text{ tonne}$ (we include the total final post-conversion surface area insofar as we also include the total footprint due to conversion). Therefore, for this field, the biodiversity footprint in relation to the quantity of wheat produced is:

$$MSA_{tot}(wheat) = \frac{161.5}{0.33} = 489.4 \text{ m}^2 \text{MSA/t}$$

The example of the wheat field is a useful pedagogic tool to illustrate the allocation rules. However in practice, the biodiversity footprint of agricultural raw materials is not calculated at the scale of a field, but for the 259,200 terrestrial grid cells of the globe. The results for each grid cell are aggregated by country to determine national footprints for different agricultural practices. At this stage only five types of agricultural

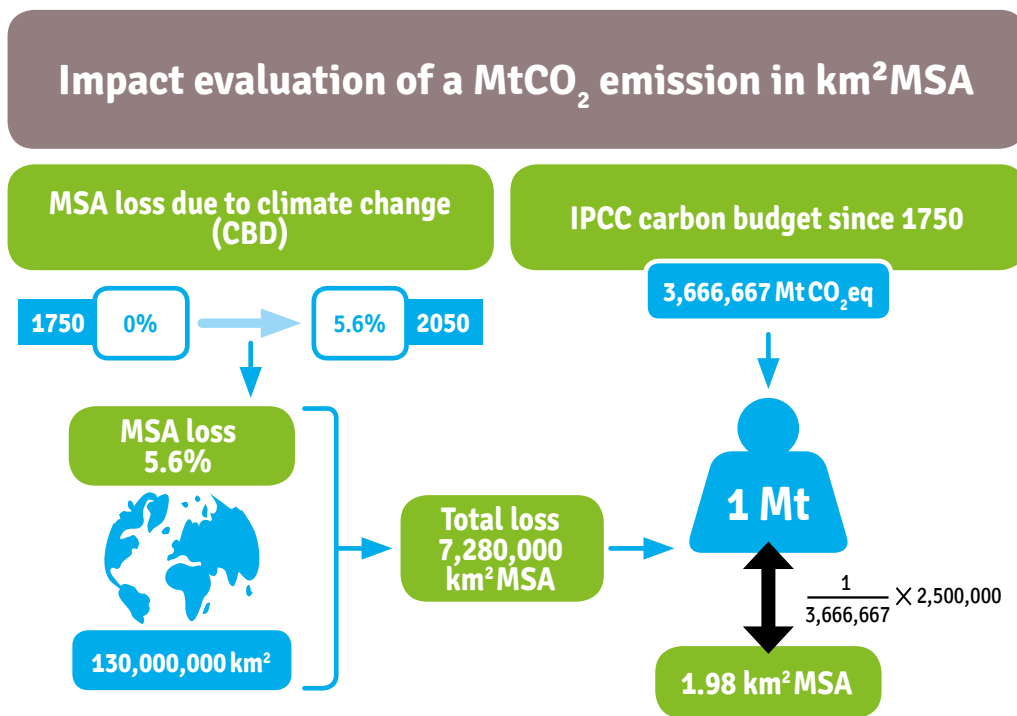


Figure 12: Calculation of the artificialization caused by emission of a megaton of CO₂

practices (corresponding to the five cropland types in GLOBIO) are differentiated. Granularity for crop farming is obtained thanks to FAO data which allow annual national crop yields to be calculated. The biodiversity footprint of a given quantity of a given commodity is then calculated based on 1) the national footprint previously calculated and 2) the share of the implicit surface area required for production in the total agricultural area in the country. This process is explained in Figure 13.

5.3 Application to an agricultural commodity: soya

The computation of raw materials biodiversity footprint is illustrated hereafter with the example of soya. GBS™ methodology is run on the 10 biggest soya producers. This section presents the results and their limitations.

5.3.1 Results

The type of agriculture (*i.e.*, intensive, low-input or irrigation-based) is not specified here as global national output data produced by the FAO do not present this level of granularity. Therefore, the total national area dedicated to agriculture is included in this analysis.

The choice of soya is relevant only at the average national yield level as no world land-use map broken down by crop type exists. Nevertheless, as is the case here for major producers, soya is one of the dominant crops grown and is well represented within the national overview included in the GBS™ methodology. Results are expressed in m²MSA by tonne produced and grouped together in the Table 3.

5.3.2 Discussion

Total impacts by tonne produced vary within a range of between a few m² (negative) to around a hundred m² (positive). Recall that a negative number represents a biodiversity gain. MSA loss in cultivated areas varies between -0.2 % in the USA and 2.4% in Bolivia. In other words, every year, the total impacts on biodiversity of growing soya in Bolivia are equivalent to the artificialization of undisturbed natural areas equal to 2.4% of the cultivated areas. Put another way, at this rate soybean cultivation in Bolivia will cause Bolivian croplands to double - at the expense of artificialization of natural areas - in 26 years' time. Conducting the same exercise for Argentina where the annual rate of artificialization is 0.6 % leads to a 116 years' time.

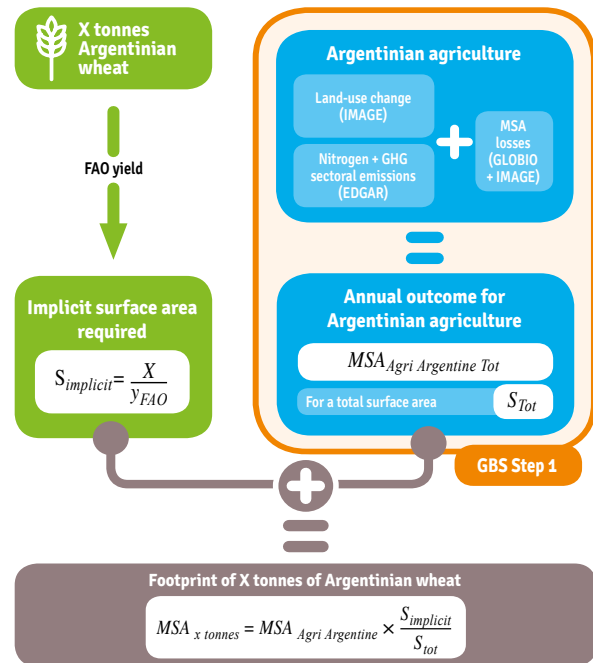


Figure 13: Diagram illustrating the methodology on the example of Argentinian wheat

With two exceptions, *i.e.*, India and the USA, land-use change is by far the dominant driver. Biodiversity lost through land conversion is due mostly to the conversion of natural areas to cropland and forestry. Therefore, the potential risk of deforestation is factored in, together with its equivalent for other natural areas such as grassland, tundra or arctic wasteland. Moreover, this approach based on potential future land conversion factors in the biodiversity gains and losses due to a change in use, *e.g.*, moving from low-input to intensive agriculture, or from a harvested forest to a plantation.

The predominance of land-use is offset to a certain extent by other spatially-related impacts, namely fragmentation and encroachment. We need to bear in mind that these impacts may be negative because, as seen previously, two conflicting dynamics are at work. On the one hand, because of the spatial growth in human activities, natural areas are more and more fragmented and subject to encroachment. But on the other hand, the global surface of these natural areas is shrinking and consequently, impacts related to fragmentation and encroachment are being applied to a smaller area. So, at one extreme, if a fragmented natural area subject to encroachment disappears, we observe a biodiversity gain related to these drivers. However, this gain is much smaller than the loss suffered due to conversion. In this example, the decrease in area is predominant for all countries - which explains the negative impacts - but this does not mean that natural areas will be less fragmented in 2050. Considering the sum of the spatial

Table 3: Biodiversity impacts of soya in the ten biggest soya producers

Country	MSA loss (MSAm ² /tonne)							MSA loss in % cultivated area	MSA% 2010	Annual yield (tonnes/ha)
	Total	In protected areas	Land use	Nitrogen deposition	Fragmen-tation	Encroach-ment	Climate change			
Paraguay	36.2	1.6	38.5	0.2	-0.3	-3.8	1.6	1.0%	65.3%	2.9
China	17.2	4.0	17.7	0.0	-0.7	-3.6	3.8	0.3%	60.1%	1.8
Brazil	14.4	1.7	14.1	-0.0	-0.2	-1.1	1.7	0.4%	67.3%	2.9
Argentina	23.3	0.7	25.4	0.0	-0.4	-2.5	0.8	0.6%	87.6%	2.8
United States	-6.4	0.5	-4.8	-1.1	-0.4	-0.7	0.6	-0.2%	53.5%	3.2
India	13.2	4.9	5.2	7.4	-1.1	-2.6	4.3	0.1%	39.7%	1.0
Uruguay	54.2	1.7	57.2	0.0	-0.4	-4.2	1.7	1.3%	37.5%	2.4
Ukraine	16.1	0.4	18.8	0.0	-0.5	-2.5	0.3	0.3%	23.4%	2.2
Bolivia	98.0	3.4	97.2	0.3	-0.1	-2.6	3.1	2.4%	77.3%	2.4
Canada	51.0	0.4	51.0	0.3	-0.7	0.0	0.4	1.4%	85.7%	2.7

pressures is therefore more appropriate and provides an integrated evaluation of the impacts caused by landscape changes.

The predominance of land conversion within the overall impact tends to favour high-yield crops. This highlights the fact that land consumption is the major agriculture-related issue so that sustainable increases in yields in countries where they are low is a major challenge for the agricultural sector over the coming years. However, the challenges are different in the countries where yields are already high. In this example, the correlation between yield and impact is weak and not significant⁽¹⁴⁾. Canada for example presents one of the highest yields and one of the highest impacts as well. Similarly, Uruguay and Bolivia have similar yields, but calculated impacts are very different. Room for improvement of the methodology remains to allow practices discrimination, especially for developing countries. The methodology already reflects intensity differences due to chemical inputs *via* the “atmospheric nitrogen deposition” driver, and the carbon impact of practices *via* GHG emissions. Yet a refined vision of biodiversity impacts related to different agricultural practices would be worthwhile.

Several research projects focusing on this topic are in progress though no global, spatialized and centralized database of agricultural practices exists.

The case of the United States is interesting and reflects the phenomenon of land abandonment fairly common in developed countries. As agricultural lands turn back into natural areas, biodiversity increases. The gain is overestimated here because the model allocates an MSA of 100% to the newly-converted natural areas immediately. Therefore, without stating firmly that soya production in the United States is favourable to biodiversity, we can say that soya production poses less risk of additional impacts on biodiversity in this country, mainly because the agricultural lands there are contained. This brings us on to the question of scale as a big rise in demand will distort the model's predictions.

India is also a case in point. The overall impact is one of the lowest but shows a predominance of impacts due to atmospheric nitrogen deposition. This is the consequence of the forecasted high intensification of Indian agriculture involving the conversion of low-input farms into intensive or irrigation-based ones. This poses however limited pressure on natural areas. These predictions are largely based on socio-political factors. The big downside of this organized intensification is

(14) Pearson Test: cor = 0.04, p-value=0.95

the massive use of synthetic fertiliser that weighs on the overall outcome due to pressure from atmospheric deposition and climate change.

The Brazilian case is also puzzling. One would expect a country grappling with deforestation issues to depict a high impact on biodiversity, but Brazil actually comes in as the country where production has the third lowest impact. This low impact can be explained by the fact that the model predicts deforestation of primary forests to mainly serve harvested forest areas. Consequently, deforestation is allocated to timber production and not to agricultural raw material production. Intensification of agriculture did occur but concerned mainly cultivated grassland, generating less biodiversity impact as this land-use is already associated to relatively poor biodiversity. The problem of impact transitivity appears here: if agricultural demand was lower, grasslands could be turned into harvested forests and lessen the pressure on natural areas. The issue of the initial (undisturbed) ecosystem also arises here. It is because Brazil has been subjected to major deforestation over the past few decades - in favour of grasslands used for livestock grazing - that it has less need for agriculturally-driven land conversion today. However, comparing modelled impacts with biodiversity intactness in 2010 reveals that the case of Brazil is pretty isolated. Indeed, the correlation between initial biodiversity intactness and predicted biodiversity erosion is not significant⁽¹⁵⁾.

In conclusion, the precision of the results is sufficient to highlight significant differences between countries, paving the way for potential use in decision-making processes.

5.4 Limits relating to the biodiversity footprint of raw materials

5.4.1 Limits related to the GLOBIO model

Pressure-impact relationships in the GLOBIO model are based on a limited number of studies and do not therefore cover all biomes or represent all species, thus introducing a bias towards most studied species and ecosystems. For example, regions where rapid land conversion is ongoing like Europe or South-East Asia are under-represented. Similarly, papers selected to support the study of the impact of infrastructures in tundra and boreal forest mainly focus on birds and

mammals, neglecting plants and insects. Studies of nitrogen deposition were mainly conducted on plants in temperate ecosystems. As regards climate change, the EUROMOVE model does not factor in fauna and only the main biomes are studied. However, the strength of the meta-analysis lies in its evolutive features and its ability to incorporate new studies as and when these become available.

A certain number of environmental drivers impacting biodiversity are ignored. Biotic exchanges (invasive species) and overexploitation are major factors in biodiversity loss (Sala OE. et al., 2000) that have not been factored into the model. Neither have frequency of wildfires and extreme events, chemical pollution or soil degradation.

Statistics published by the FAO (2006) and research based around spatial imagery (Bartholome E. et al., 2004) (Fritz S., 2008) demonstrate that uncertainties still surround the use of agricultural land. The uncertainties over forecasted climate change scenarios are also large and have been widely documented in IPCC reports.

Lastly, at this stage, the impacts of the different pressures are assumed additive. Considering other relationships between the pressures, for instance positive or negative correlations, may impact the results.

5.4.2 Shortcomings of the reallocation rules

Reallocation rules are based on strong assumptions and could be improved, notably by refining the mapping of spatial-type drivers. Furthermore, pressure from infrastructure is not factored into this first version of the GBS™ methodology. Allocating the share of infrastructure to diverse economic activities is a complex problem both in terms of mapping and in terms of the underlying economic rationale. This work will be carried out in the medium term when research into other raw materials and the value chain analysis is further advanced. Progress in these two areas will provide an overall vision of economic activities, and a better fit with the way in which infrastructure is used.

(15) Pearson Test, cor=0.36, p-value=0.31

6 GBS™ methodology: on-going developments and future challenges

6.1 On-going developments

As regards calculating the biodiversity footprint of raw materials, two major developments are in progress with the aim of enhancing the quality of the biodiversity footprint itself and extending the scope of raw materials analysed. In the meantime, work is under way on the second stage of the GBS™ methodology aiming to analyse business’s value chains.

6.1.1 Improving the quality of the raw materials footprint

A WEIGHTING BASED ON SCARCITY OR VULNERABILITY INDICES

An optional weighting feature that factors in the ecological value of ecosystems is already available in the GBS™ methodology. In the standard version, all types of ecosystems have the same value. Hence, the degrada-

tion of 1 m² of pristine forest and 1 m² of tundra are regarded as equivalent. This premise is built on an ecological perspective, particularly a functional approach in which any ecosystem in good condition is as good as any other. However, it would be interesting to see how weighting natural areas by species richness, levels of endemism, or threat or protection levels impacts the results. The GLOBIO model includes a “biome” and an “area of protected space” field for each cell. Therefore, it is possible:

- to incorporate the dimension of protected space into the model, and
- introduce a weighting by average specific abundance of biomes.

Moreover, working with spatialized data makes it relatively easy to introduce weightings based on mapped data such as the IUCN’s different degrees of extinction risks, biodiversity hotspots or indices like the LBII that factor in species vulnerability.

Table 4 compares the biodiversity footprint of soy production with and without introducing a weighting accounting for biomes’ species richness.

Table 4: Comparison between the footprint of soya production calculated with and without weighting

MSA loss (MSAm ² /tonne)									
Country	With weighting		Without weighting		Difference for each driver				
	Total	In protected areas	Total	In protected areas	Land use	Nitrogen depositio-nazotés	Fragmen-tation	Encroach-ment	Climate change
Paraguay	46.7	1.6	36.2	1.6	11.8	0.0	-0.0	-1.1	-0.2
China	16.2	3.9	17.2	4.0	-0.5	-0.1	-0.0	0.0	-0.4
Brazil	16.6	1.7	14.4	1.7	2.5	-0.0	-0.0	-0.1	-0.2
Argentina	22.6	0.7	23.3	0.7	-0.3	0.0	-0.0	-0.2	-0.1
United States	-6.3	0.5	-6.4	0.5	0.3	-0.1	-0.0	-0.1	-0.1
India	12.1	4.8	13.2	4.9	-0.5	-0.4	0.1	0.1	-0.4
Uruguay	65.4	1.7	54.2	1.7	12.4	0.0	-0.1	-0.9	-0.2
Ukraine	16.3	0.4	16.1	0.4	0.2	-0.0	-0.0	-0.0	-0.0
Bolivia	109.2	3.5	98.0	3.4	11.7	0.1	0.0	-0.2	-0.3
Canada	29.8	0.4	51.0	0.4	-21.2	0.0	0.1	-0.1	-0.0

B FACTORING IN PRESSURES FROM CHEMICAL POLLUTION

Several environmental drivers impacting biodiversity are ignored at this stage of the methodology's development. Pollution due to discharges of chemicals into land or aquatic ecosystems has a significant impact on biodiversity (Zaninotto V., 2014) and including it in the analysis is essential. The general idea would be to rely on databases and tools developed within the scope of ecotoxicology studies and to draw on LCA data and analyses with a similar approach. The main challenge lies in expressing PDF values in MSA.

6.1.2 Extending the scope of raw materials analysed

The second major project is the expansion of the scope of the biodiversity footprint to all raw materials. At present, only agricultural commodities and forestry raw materials are covered.

The footprint from livestock production needs to be analysed in the same way as crop-type agricultural commodities. The analysis can be broken down into two parts. First, the direct footprint resulting from on-farms activities and second, the indirect footprint generated mainly from animal foodstuffs. The work carried out by the FAO, notably the Global Livestock Environmental Assessment (GLEAM) model, will allow the constitution of a range of technical agricultural data on food and medicinal requirements, types of foodstuffs, growth and waste generated by different types of livestock along their life cycle. Next, the preliminary work on the footprint of grazing land and crop farming will be used to translate this technical data into a biodiversity footprint. From this first step on, the aim is to maintain maximal granularity at the agricultural practice level with a view to giving future users the widest possible range of trade-offs. For aquaculture, two prerequisites are needed before drawing up an *ad hoc* methodology: conducting research into available data and refining expertise on aquatic biodiversity. Aquatic biodiversity and the related drivers have recently been integrated into the GLOBIO model and their mainstreaming into GBS™ methodology is underway.

Extractive raw materials (minerals, energy) will be analysed in the near future. The first objective is to calculate the footprint at the extraction site level. As for agricultural raw materials, it is planned to evaluate the contribution of extraction processes to each driver using global databases. To this end, the US Geological Survey (USGS) public database can be used. This database references all extraction sites throughout the world and for each one, documents information such as ore type and density, mining type, annual volumes extracted, age of the mine, etc. An initial analysis

based on a simple geometric approach is contemplated to assess the contribution of extractive raw materials to spatial drivers. Identification of the infrastructures used by extraction site may rely upon the crossing of USGS data with a world infrastructure map. Finally, GHG emissions documented in the EDGAR database will be used with the same method as that developed for agricultural commodities, distinguishing between local and global impacts. Once this first version has been delivered, the results could potentially be refined thanks to the private databases like Intierra used and kept up to date by stakeholders from the sector.

6.1.3 An essential development: integrating the value chain analysis

Sooner or later, all economic activities require the production of raw materials. The initial work involved in building a raw materials footprint database by country will underpin the methodology for calculating a company's biodiversity footprint.

The life cycle analysis concept is at the core of the development of a number of tools, two of which are used in the GBS™ methodology, *i.e.*, Life Cycle Analysis (LCA) and matrix-based input-output models.

A DEVELOPMENT PATHS USING LIFE CYCLE ANALYSIS (LCA)

LCA is a tool designed to identify and assess the environmental impact of a material, product, process or service throughout its life. The environmental impact includes the materials and energy resources necessary to create the product as well as the waste and emissions generated during the production process. Examining the product's entire life cycle provides a more comprehensive overview of its actual impact on the environment and of the possible trade-offs at different stages of the life cycle. These results may be useful in identifying high environmental impact zones – hotspots – and evaluating and enhancing product manufacturing processes.

Traditionally, a life cycle is defined as a linear process starting with the extraction of raw materials (crude oil, cereal, etc.). These raw materials are then converted into finished materials: cereal is turned into flour, crude oil into plastic, etc. The finished materials are manufactured or assembled into a final product. Following the example, flour is used to make bread, plastic to make a car part. The fourth stage comprises the use of the product over the consumption period. Finally, the fifth stage is the product's end of life encompassing recycling and elimination. A sixth stage consisting in distribution and transport of the product between the other five stages may be included. Production activities during all

the stages require materials and energy, and generate waste and emissions. Evaluating the impacts is a two-step process that distinguishes “midpoint” impacts quantifying the direct physical effects produced by the substances emitted or consumed, from “endpoint” impacts which evaluate the consequences for mankind or ecosystems. For instance, “midpoints” include greenhouse effect, ozone layer depletion, toxicity and eutrophication. Endpoints describe impacts on human health, quality of ecosystems and resources depletion.

The traditional LCA broken down by process has two main shortcomings. The first one is the difficulty in setting the boundaries of the analysis. For instance, the LCA of a cardboard cup may include the cardboard, glue and the energy used by production machines. Yet to be exhaustive, it should also consider all the products and processes needed to make these same machines, and so on and so forth. Circumscribing the analysis is thus necessary, inevitably limiting the scope of the results and systematically undervaluing the impacts of life cycle. The second issue relates to circular effects: the production of a product requires that same product. For example, manufacturing steel machines requires steel while extracting steel requires steel machines, etc. In theory, life cycles of all materials and processes involved in the conception of a single product should be included in the analysis. Hence, performing an LCA by process is a complex and time-consuming task entailing assumption making.

The use of LCA analysis in the GBS™ methodology is intended to be simple and responds to a dual objective. The first one concerns raw materials and seeks to factor in the basic transformation processes inherent to some of them. For instance, timber production requires the use of energy and minerals that are not accounted

for in the footprint of wood. LCA factors in the transformation processes involved in the production of such standardized materials.

The second objective is the use of materials balances for converted products provided by LCA. A material balance is the list of raw materials in production processes. The idea here is to identify a number of key products in terms of biodiversity impacts, to constitute a database of their materials balance based on LCA and to use this database to estimate their biodiversity footprint.

B DEVELOPMENT PATHS FOR USING INPUT-OUTPUT MODELS

Input-output-type economic models provide a mathematical representation of monetary transactions between economic sectors. Consider the automobile sector for instance. The inputs of the automotive sector are the outputs of the sectors producing the metal sheets, bumpers, tyres, mats, and even the computers (for designing the cars) or the electricity (for powering the factories). And the sectors that produce the metal sheets, bumpers, tyres, etc., require inputs for their operations that are outputs of other sectors, and so on.

Input-output models are generally presented in matrix form. Column entries represent inputs to an industrial sector, row entries represent outputs. The intersection shows the economic value of the output of the row sector, which is taken as the input of the column sector (see Figure 14). As such, input-output models have two interesting features: first, they can handle cases where the output of a sector is also needed as an input for this same sector, thus avoiding the issues of circularity raised in relation to LCA. Second, the matrix form is easy to manipulate and direct, indirect and total effects can be calculated rapidly. Direct effects

	Sector A	Sector B	Sector C	Consumer	Total productions
Sector A	Total economic value of the output of sector A used as input in sector A	Total economic value of the output of sector A used as input in sector B	Total economic value of the output of sector A used as input in sector C	Total economic value of the sales of sector A	Total economic value of the productions of sector A
Sector B	Total economic value of the output of sector B used as input in sector A	Total economic value of the output of sector B used as input in sector B	Total economic value of the output of sector B used as input in sector C	Total economic value of the sales of sector B	Total economic value of the productions of sector B
Sector C	Total economic value of the output of sector C used as input in sector A	Total economic value of the output of sector C used as input in sector B	Total economic value of the output of sector C used as input in sector C	Total economic value of the sales of sector C	Total economic value of the productions of sector C
Total consumptions	Total economic value of the consumptions of sector A	Total economic value of the consumptions of sector B	Total economic value of the consumptions of sector C		

Figure 14: Illustration of an input-output model for a three-sector economy

are level 1 transactions, *i.e.*, transactions between a sector and the sectors that have supplied their outputs. Indirect effects are level 2 and level 3 transactions, *i.e.*, transactions between all sectors that have arisen from level 1 transactions. Total effects represent the sum of direct and indirect effects. Therefore, these models incorporate all levels, thus avoiding the issue of scope definition.

The first input-output models were designed on a national scale for economic planning and national accounting purposes. These models have since been taken up and international versions developed, linking all sectors of all countries. Whereas the first models only considered monetary flows between the different sectors, certain models now include data on the flows of materials and it is precisely these data that could be used in the GBS™ methodology. Sector-specific and national biodiversity footprints could thus be deduced from the footprint of materials flows. This sector-based tool supports two main applications of the GBS™ methodology:

- **calculating the footprint of a financial asset portfolio.** Investors are used to analysing their risks and exposure by sector and by country. This analytical framework will provide them with an initial estimate of their biodiversity risk,

- **calculating a generic footprint** for a product or company with limited information. For example, determining the origin of all the components of a computer is difficult whereas the origin of the computer itself is always documented. Thus, in the absence of precise information about the manufacturer, the average footprint for the “IT products” sector for the manufacturing country may be used to calculate a default product footprint. The approach could be applied to a company, breaking down its activity by country and by economic sector to calculate a generic footprint. For companies whose shares are listed on financial markets, this sector-based breakdown of activities is generally available, so it is possible to provide an initial evaluation of their footprint that may subsequently be refined using more specific, public information or disclosures provided by the company itself.

6.2 Future challenges

6.2.1 Factoring in marine biodiversity

In the GLOBIO model, marine biodiversity is only included *via* the management of fisheries resources. Integrating marine biodiversity more comprehensively is a complicated task that quickly runs into data

availability problems. Uniformity of metrics is also an issue: units expressed in surface area may be suitable for shallow coastal areas but not for vast oceans.

6.2.2 Factoring in overexploitation

Similarly, pressure from overexploitation *per se* is ignored. It is however partly accounted for in land-use insofar as an intensity criterion is included, both for agriculture and forestry. Similarly, in the case of encroachment, establishing buffer zones between natural and man-made lands in which biodiversity has been degraded reflects ease of access to the natural areas favouring hunting, tourism or resource development. As regards fisheries, GLOBIO already includes an approach based around population dynamics and factoring in sustainability criteria for managing natural resources is identified as a key issue. This latter point will be the focus of a broader study planned for a later stage into a more refined basis for integrating practices, labels and certifications.

6.2.3 Factoring in pressure from invasive species

Invasive species will be harder to incorporate. MSA makes it possible to capture invasive phenomena insofar as only species originally present in the ecosystem are considered. For climate change, the biodiversity loss caused by shifting geographic distributions is partly due to the arrival of new species better suited to new climatic conditions that may theoretically be considered as invasive in this respect. However, the model does not take account of the principal phenomenon here, namely the introduction into an ecosystem of an exotic species that develops to the detriment of endemic species. We know of no research done to map and quantify the phenomenon on a global scale nor to link it to economic activities. This is of course a tricky exercise as such introductions are erratic and due to multiple factors, thus complicating their modelling and allocation to a specific economic activity. However, as a first approximation, the process of allocation to economic activities could be similar to that used for infrastructure by considering that invasion processes are mainly bound up with different forms of transport, once again raising the issue of allocating transport requirements between different economic sectors. This would yet require that quantified global data on biodiversity loss driven by invasive species actually exist.

CONCLUSION AND PROSPECTS

Access to summary aggregate information that reflects inter-related links between business and biodiversity would meet the expectations of a wide range of different stakeholders: public bodies, civil society, investors and businesses themselves. To meet this challenge, a number of complimentary initiatives are currently focusing on this topic. The GBS™ methodology proposes a quantitative biodiversity footprint that covers the entire value chain and is based on a biodiversity database built around the PBL's flagship project, the GLOBIO model. Synergies with existing initiatives will enhance the reliability of biodiversity input data (LBII), point up links between modelled and observed data (Red List, LPI) and provide solutions for integrating biodiversity into more general analytical tools (LCA, input-output models).

By using the results of the GLOBIO model as input data, GBS™ incorporates leading-edge scientific knowledge in a synthetic manner, linking different anthropogenic drivers to their biodiversity impacts on a global scale. In addition, it uses the IMAGE model to factor in economic, demographic, climate and political parameters thus emphasizing that the issues relating to biodiversity and ecology go way beyond the realm of the physical and chemical sciences. Finally, thanks to the predictive capabilities of the IMAGE model, GBS™ methodology is capable of quantifying risk areas and factors for future impacts.

Nevertheless, it is important to bear in mind that the IMAGE and GLOBIO models were designed for large-scale applications and the use of GBS™ methodology must comply with this structural constraint. GBS™ is designed to provide an overall and synthetic vision of the biodiversity footprint of economic activities. It is not intended to replace local indicators which are best

sued to local or on-site biodiversity assessments. This idea of reconciling different scales is key and it is essential that the GBS™ results are consistent with analyses conducted on a local scale, making it possible to summarize the data while losing as little information as possible.

Several challenges remain, most notably integrating marine biodiversity and drivers that are partially (or totally) neglected. For the moment, no fully satisfactory solution has been found to address these challenges. These issues shared by a number of initiatives on the subject and numerous projects are however in progress and suggested solutions will help drive reflections and exchanges concerning GBS™ methodology over the coming years. The advantage of this methodology is its capacity to handle evolving data on the representation of environmental drivers impacting biodiversity (or even change this representation).

Finally, to ensure that GBS™ responds to user needs, it must be able to track the impacts of the actions deployed so it needs to differentiate as clearly as possible between a multitude of different practices. The first version presented in this study should be seen as a “skeleton” that needs to be refined before it is fully relevant. Two projects are currently being conducted in parallel within the scope of B4B+ Club and CDC Biodiversité. First, the theoretical enhancement of GBS™: more environmental drivers impacting biodiversity need to be included, the scope of raw materials analysed should be expanded and the link between company's activities and raw materials needs remains to be made. Second, the operational relevance of the footprint needs to be enhanced thanks to the involvement of future users, i.e. businesses. This is the aim of the B4B+ Club.



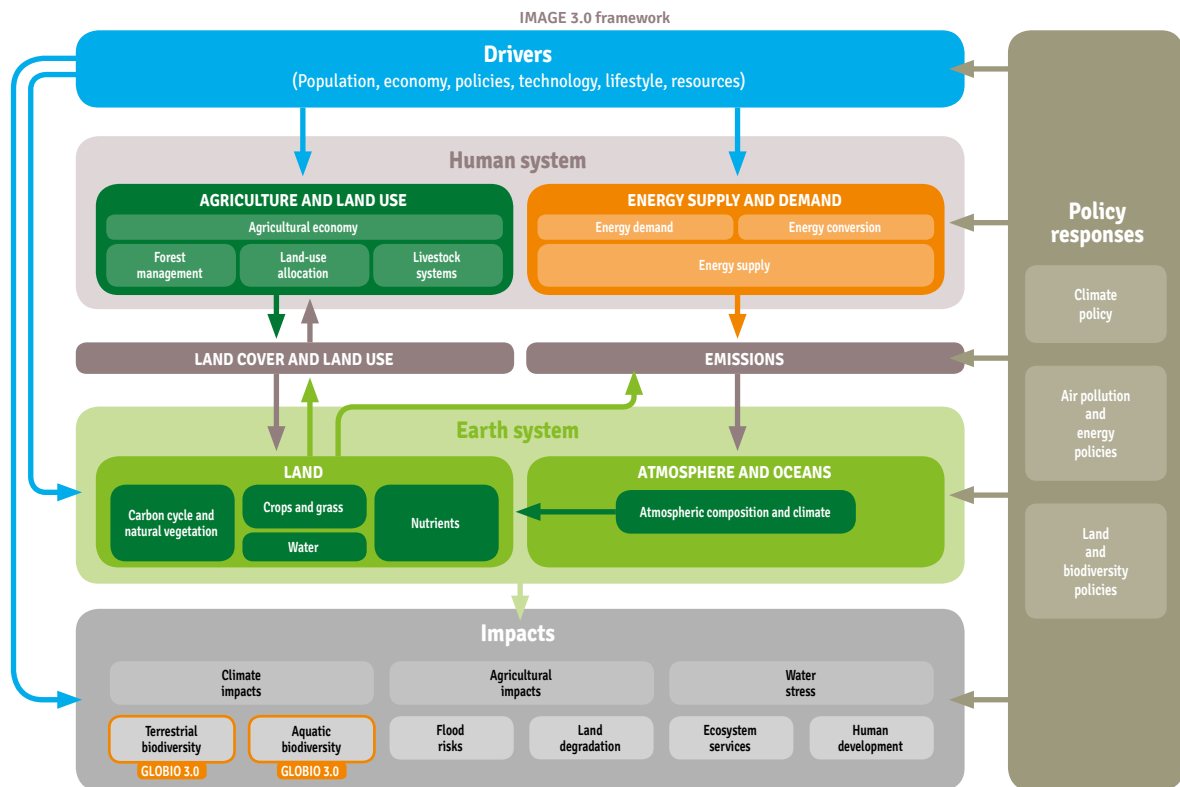
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GLOSSARY

LCA	Life Cycle Analysis
CBD	Convention on Biological Diversity
CISL	Cambridge Institute for Sustainable Leadership
IMAGE	Integrated Model to Assess the Global Environment
EDGAR	Emissions Database for Global Atmospheric Research
FAO	Food and Agriculture Organization
GHG	Greenhouse Gas Emissions
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
LBII	Local Biodiversity Intactness Index
LPI	Living Planet Index
MEB	Mission Economie de la Biodiversité
MSA	Mean Species Abundance
NCC	Natural Capital Coalition
NCFA	Natural Capital Financial Alliance
NCP	Natural Capital Protocol
PBL	Netherlands Environmental Assessment Agency
PDF	Potentially Disappeared Fraction
TEEB	The Economics of Ecosystems and Biodiversity
UNEP-FI	United Nations Environment Programme - Finance Initiative
UNEP-WCMC	United Nations Environment Programme - World Conservation Monitoring Center
WBCSD	World Business Council for Sustainable Development

APPENDICES

Diagram of the IMAGE model



Assumptions underpinning the “trend” scenario in IMAGE

The “trend” scenario is a standard that helps in understanding the context and remaining challenges for achieving the objectives set out in the CBD. It assumes that key variables change little and that socio-economic arrangements remain similar without any major shift towards sustainable development policies. This implies that economic development and globalization remain the principal objectives. Consumption of food, raw materials and energy continue to increase even though a phenomenon of saturation appears in highest income countries. No ambitious environmental policy is deployed except for those that contribute directly to better human health like reducing air or water pollution. Innovation continues at the same pace. More precisely:

- in 2050, the global population is 9.2 billion (NB: 7 billion in 2010),
- global GDP quadruple between 2010 and 2050,
- food consumption increases by a factor of approximately 1.7,
- consumption of timber increases by a factor of approximately 1.3,
- agricultural land (cropland and grazing land) covers 4 million km² in 2050 (*i.e.*, 10% increase),
- forest areas decrease by 1.5 million km²,
- energy use increases by a factor of 1.7,
- water use increases by a factor of 1.6,
- concentrations of greenhouse gases exceed 700 ppm in 2050 and the Global Mean Temperature Increase (GMTI) reaches almost 2.5°C.



BIBLIOGRAPHY

- Alkemade R. et al. (2009) *GLOBIO 3: A framework to investigate options for reducing global terrestrial biodiversity loss*, *Ecosystems* 12, 374-390.
- Bakkenes M. et al. (2002) *Assessing effects of forecasted climate change on the diversity and distribution of European higher plants for 2050*, *Global Change Biology* 8 (4), 390-407.
- Bakkenes M., Eickhout B., Alkemade R. (2006) *Impacts of different climate stabilisation scenarios on plant species in Europe*, *Global Environmental Change* 16, 19-28.
- Bartholomé E. et al. (2004) *S. Global land cover for the year 2000*.
- Becky Chaplin-Kramer, J. G. (2016). *Biodiversity and ecosystem services in environmental profit & loss accounts*.
- Bouwman A.F. et al. (2002) *A global analysis of acidification and eutrophication of terrestrial ecosystems*, *Water, Air, and Soil Pollution* 141 (1-4), 349-382.
- CDC Biodiversité. (2015). *Biodiv' 2050 #7 : Entreprises et biodiversité : risques et opportunités*.
- CDC Biodiversité. (2015). *Biodiv'2050 #6 : Mobilisation des ressources pour la biodiversité et contribution du secteur privé*.
- CDC Biodiversité. (2015). *Les cahiers de Biodiv' 2050 #7 : Entreprises et biodiversité : quels outils pour quelles décisions ?*
- Constanza R. (2014) *Changes in the global value of ecosystem services*, *Global Environmental Change* 26, 152-158.
- CREM, PRé Consultants. (2016). *Towards ASN Bank's Biodiversity Footprint*.
- Di Fonzo M. et Cranston G., (2017), *Healthy Ecosystem metric framework: Biodiversity impact*, *University of Cambridge Institute for Sustainability Leadership (CISL)*, Working Paper 02/2017
- Di Fonzo M. et Hime S. (2017), *How businesses measure their impacts on nature: A gap analysis*, *University of Cambridge Institute for Sustainability Leadership (CISL)*, Working Paper 01/2017
- Dixon, J., Gulliver A., Gibbon D. (2001) *Farming Systems and Poverty: Improving Farmers' Livelihoods in a Changing World*, *FAO & World Bank*, Rome, Italy & Washington, DC, USA.
- Epe. (2016). *Entreprises et biodiversité – gérer les impacts sur la chaîne de valeur*.
- Fritz S. et See L. (2008) *Identifying and quantifying uncertainty and spatial disagreement in the comparison of Global Land Cover for different applications*, *Global Change Biology* 14 (5), 1057-1075.
- Gerardo Ceballos, P. R. (2017). *Biological annihilation via the ongoing sixth mass extinction signaled by vertebrate population losses and declines*.
- Hudson, L.A. et al. (2014) *The PREDICTS database: a global database of how local terrestrial biodiversity responds to human impacts*, *Ecology and Evolution* 4 (24), 4701-4735.
- I care, eva. (2014). *Comment utiliser les flux, indicateurs et méthodes acv existants pour traiter l'impact sur la biodiversité*.
- Ionescu, C. (2016). *Biodiversité et stratégie des organisations : construire des outils pour gérer des relations multiples et inter-temporelles*.
- IPBES, S. F.-M.-M. (2017). *The methodological assessment report on scenarios and models of biodiversity and ecosystem services*.
- Kareiva P. et al. (2007) *Domesticated Nature: Shaping Landscapes and Ecosystems for Human Welfare*, *Science* 316, 1866-1869
- Braat L. et ten Brick P. (2008) *The cost of Policy Inaction: The case of not meeting the 2010 biodiversity target*.
- Leemans R. et Eickhout B. (2004) *Another reason for concern: regional and global impacts on ecosystems for different levels of climate change*, *Global Environmental Change* 14, 219-228.
- Olivier J, J.-M. G. (s.d.). <http://edgar.jrc.ec.europa.eu/methodology.php>.
- Parker, C., Cranford, M., Oakes, N., Leggett, M. ed., 2012. *The Little Biodiversity Finance Book*, *Global Canopy Programme*; Oxford.
- PBL Netherlands Environmental Assessment Agency. (2014). *CBD Technical Series 79: How sectors can contribute to sustainable use and conservation of biodiversity?*
- PBL Netherlands Environmental Assessment Agency. (2006). *An overview of IMAGE 2.4*.
- PBL Netherlands Environmental Assessment Agency. (2007). *CBD Technical Series 31 : Cross roads of life on earth, exploring means to meet the 2010 Biodiversity Target*.
- PUMA. (2010). *Environmental Profit and Loss Account for the year ended 31 December 2010*.
- Sala O.E. et al. (2000) *Global Biodiversity Scenarios for the Year 2100*, *Science* 287, 1770-1774.
- Steffen W et al. (2015) *The trajectory of the Anthropocene: The Great Acceleration*, *The Anthropocene Review*, 1-18
- Verboom J. et al. (2007) *Combining biodiversity modeling with political and economic development scenarios for 25 EU countries*, *Ecological Economics* 62, 267-276.
- Zaninotto V., F. E. (2014). *Pollution atmosphérique, biodiversité et écosystème*.

Unlike climate change mitigation which is gradually mainstreamed into business strategies and activities, biodiversity still struggles to be recognized as a major issue for businesses and financial institutions due to its complexity. Yet relations between business and biodiversity are on the verge of a major paradigm shift. At a time when the private sector must step up and play its full role in helping to achieve the objectives laid down by the international community in terms of stopping biodiversity loss, CDC Biodiversité has come up with an innovative methodology that enables companies from all sectors to quantify their impacts on ecosystems by using a single indicator. This indicator, named the Global Biodiversity Score (GBS), is expressed in surface area of destroyed pristine natural areas. The methodology makes it possible to quantify a business's biodiversity footprint all the way along the value chain. It has been developed jointly with CDC Biodiversité's B4B+ Club (club of pro-biodiversity businesses) and seeks to help drive the transformation of interactions between economic stakeholders and the living environment in a world in which integrating natural capital – and biodiversity in particular – into decision-making processes has taken on the utmost urgency.