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SYNTHESIZING THE SCIENTIFIC EVIDENCE TO INFORM THE DEVELOPMENT OF THE POST-2020 GLOBAL FRAMEWORK ON BIODIVERSITY

Note by the Executive Secretary

1. The Executive Secretary circulates herewith, for the information of participants in the twenty-fourth meeting of the Subsidiary Body on Scientific, Technical and Technological Advice, an information document synthesizing scientific evidence relevant to the development of the post-2020 global biodiversity framework. The document has been prepared by a group of experts convened by the Earth Commission in collaboration with Future Earth and the Secretariat of the Convention on Biological Diversity. The Group met in Davos, Switzerland, from 28 February to 2 March 2020, on the margins of the World Biodiversity Forum.

2. In decision 14/34 the Subsidiary Body on Scientific, Technical and Technological Advice was requested at its twenty-third and twenty-fourth meetings to contribute to the development of the post-2020 global biodiversity framework and in support of the work of the open-ended intersessional working group. Decision 14/34 also requires that the preparatory process for the post-2020 global biodiversity framework be knowledge-based. Among the key information sources identified were assessments prepared by relevant organizations and peer-reviewed literature.

3. The document is provided in the form and language in which it was received by the Secretariat.

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[*] CBD/SBSTTA/24/1

Synthesizing the scientific evidence to inform the development of the post-2020 Global Framework on Biodiversity

Earth Commission Meeting Report to the Convention on Biological Diversity

21 April 2020

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Executive Summary

This report is the result of a meeting which aimed to offer scientific guidance to the development under the Convention on Biological Diversity (CBD) of the post-2020 Global Biodiversity Framework focussing on its contribution to the 2030 Mission and 2050 Vision. We provide a synthesis of the scientific and technical justification, evidence base and feasibility for outcome-oriented goals on nature and its contributions to people, including biodiversity at different levels from genes to biomes. The report is structured to respond to the Zero Draft of the post-2020 Global Biodiversity Framework.

We commend:

- The focus of the 5 high-level goals on the conservation of nature (Goals a-c), its sustained provision of benefits to people (Goal d) and fair and equitable sharing of benefits (Goal e);
- The focus, at this high level, on outcomes (results to be achieved) for nature and people;
- The focus on different facets of nature (or levels of organization within biodiversity): ecosystems, species and genetic diversity within species, each of them receiving the same level of importance.

We stress:

- That these goals cannot be fully achieved in isolation. Rather, each of them contributes synergistically to the achievement of the others.
- That condensing the goals into fewer more compound goals would risk obscuring the multidimensionality of living nature and the complementarity of the outcome goals in achieving the long-term vision of the CBD.
- The need to consider all ecosystems under the double perspective of conserving nature and ensuring the long-term provision of benefits to people. “Natural” ecosystems provide essential benefits to people. At the same time, “managed” ecosystems should not be considered as “lost for nature”; they are places where certain functions of nature are managed to provide specific benefits,

- but also provide important opportunities for nature conservation and enhancing nature's contributions to people.
- The need to identify a reference year for measurement, and propose 2020 as a practical reference starting year, with the setting of goals for both 2030 and 2050.

Below, we suggest (a) possible reformulations of the outcome-oriented goals as supported by scientific evidence summarized in this report, and (b) a breakdown of critical elements to be considered for the final formulation of goals for the post-2020 Global Biodiversity Framework. Recognizing that it may not be practical to include all elements in a concise outcome goal, these elements may also be reflected in derived action targets, and in the structure for implementation and monitoring.

Ecosystems (Goal a):

No additional loss of critical ecosystems. No net loss by 2030 in both the area and integrity of all "natural" ecosystems compared to 2020, and increases of at least 20% in the area and integrity of "natural" ecosystems by 2050. No net loss of integrity of "managed" ecosystems by 2030*, and net gain by 2050.*

Critical elements:

- Take 2020 as reference year for evaluating no net loss, achieving no net loss between 2020 and 2030.
- Ensure achieving no loss of critical ecosystems, i.e., ecosystems that are rare, vulnerable or essential for planetary function.
- Ensure like-for-like compensation by having a clear ecosystem definition and no substitution between different ecosystems.
- Aim for no net loss of both area and integrity in "natural" ecosystems and no net loss of integrity of "managed" ecosystems by 2030. Integrity of "managed" areas should be increased by 2050 to ensure recovery of nature's contributions to people.
- Maintain a restoration ambition as part of the goals ("net gain in area and integrity") with implementation through integrated planning to optimize benefits for nature and people.

Species (Goal b):

Species extinction rate and extinction risk are reduced progressively by 2030 and 2050, across the whole Tree of Life, and the local abundance and distributional extent of key functional species and threatened species is stabilized by 2030 and recovered by 2050.

Critical elements:

- Reduce the rate of extinction progressively.
- Minimize the loss of evolutionary history, recognizing that species are not equal in this respect.
- Focus on threatened species to 2030 to prioritize species needing urgent attention, but for 2050, reduce extinction risk across all species, not just the most threatened.
- Re-establish population abundance within local ecological communities, rather than increasing total population abundance overall, prioritizing species with key functional roles.
- Include a qualitative statement about retention and eventual recovery of a natural distributional extent of species.

Genes (Goal c):

By 2030, genetic erosion of all wild and domesticated species is halted and, by 2050, the genetic diversity of populations is restored [to XX%] and their adaptive capacity is safeguarded.

Critical elements:

- Make explicit mention of all wild and domesticated species, including their "wild relatives".
- Make explicit reference to populations and their adaptive capacity.
- Avoid "on average" since this is very likely to set the bar too low.
- Estimating precise quantitative targets for maintaining genetic diversity may be difficult, but current knowledge suggests a minimum of 90% by 2050.

Benefits to people (Goal d):

Nature's contributions to people that are critical for a good quality of life are enhanced and secured by X [timeframe] by:

> *(i)* ***Maintaining nutritious food provisioning and improving nature's contributions underpinning it****,* ***such as pollination, pest control, eutrophication control, erosion control and soil fertility,*** *which form the basis of nutrition security.*
>
> *(ii)* ***Improving the regulation of water distribution and quality,*** *which contribute to access to safe and drinkable water.*
>
> *(iii)* ***Improving climate change mitigation through ecosystem carbon sequestration****, which is essential to meet the Paris Agreement commitments.*
>
> *(iv)* ***Enhancing coastal protection and flood mitigation by ecosystems****, which contribute to resilience to natural disasters.*
>
> *(v)* ***Enhancing the provision of physical and psychological experiences provided by nature in cities****, to contribute to mental and physical health of the world's growing urban population.*

Critical elements:

- Focus on the outcome (nature's contributions to people), not on actions (e.g. sustainable management) or quality of life (which results from NCP interacting with other factors outside the CBD's mandate).
- Consider the capacity of both "natural" and "managed" ecosystems to augment, secure and stabilize the provision of multiple NCP. We note that achieving 10-20% of native habitat area in "managed" ecosystems is likely to maximize synergies for people and nature, enhancing local NCP provision.
- Consider inter- and intragenerational equity in the distribution of benefits.

We did not address **Goal e** on equitable sharing of genetic resources, but made some general considerations in relation to equitable sharing of nature's benefits (including from ecosystems and species) in the section devoted to Goal d.

The evidence supporting these goal formulations and their critical elements is provided in the report main text and annexes. Further, we provide goal-specific "ambition tables" illustrating different levels of ambition for Goals a-d, and we show how these are dependent on each other.

Only the highest level of ambition and the consideration of all goals in a synergistic manner are sufficient to achieve the CBD's 2050 Vision.

1. Introduction

Context, purpose and scope

The year 2020 is critical for the future of nature and people. A recent global report (Díaz et al. 2019, IPBES 2019) clearly indicates a worldwide decline of nature and most of its benefits to all people, and a pervasive inequity in the distribution of such benefits among people. If these are to be addressed, the time window is narrow and action needs to be fast and ambitious. In its upcoming fifteenth meeting of the Conference of the Parties, the Convention on Biological Diversity (CBD) will set new goals and targets for governments for the next decade, and until 2050, through its post-2020 Global Biodiversity Framework (GBF).

As with the previous Aichi Targets (CBD 2010), these new goals and targets will frame and galvanize the work of nations as well as other actors in society, such as NGOs, civil society organizations and the private sector (Addison et al. 2018). Therefore, the prompt establishment of ambitious, yet realistic and science-based, goals and targets is imperative.

This is a report of a meeting organized on 28 February – 2 March 2020 by the Earth Commission in close collaboration with the CBD and Future Earth, to provide scientific input to the high-level outcome-oriented goals as proposed in the Zero Draft of the post-2020 Global Biodiversity Framework (hereafter Zero Draft). The meeting gathered 43 participants and 20 contributors whose scientific expertise would directly inform these goals. **Our aim was to provide a synthesis of the scientific and technical justification, evidence base and feasibility for outcome-oriented goals on nature and its contributions to people, including biodiversity at different levels from genes to biomes.**

The challenge of developing goals for nature and people in the 21st century has been approached from many different perspectives, from theoretical to practice-oriented, from global to placed-based, and driven by different institutional missions and disciplinary outlooks. There is also ongoing work and debate, involving many research and practitioner groups, on how to aggregate ambition to as few goals as possible, and how to bring this work to guide countries in the development of the GBF.

While differences in outlook and emphasis are healthy and likely to persist, there is a need to identify a small set of critical facets of nature on which to base the GBF, and for each of these facets, critical goals or targets that are at the same time ambitious, feasible, measurable and acceptable. This report approaches ambition, feasibility and measurability mostly from the biophysical perspective. While social, economic, governance and rights implications are crucial, we did not address them in detail due to time and expertise constraints, except for a judgement of feasibility of alternative goals (from social, economic and governance perspectives).

High-level comments pertaining to all the goals

We commend the focus of the 5 high-level goals in the Zero Draft on the conservation of nature (Goals a-c), its sustained provision of benefits to people (Goal d) and fair and equitable sharing of benefits (Goal e). This double focus on nature and nature's contributions to people[1] is powerful and aligns well with the objectives of the CBD. It reminds us that the conservation of biodiversity is equally about supporting society.

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[1] Nature's contributions to people (NCP) are all the contributions, both positive and negative, of living nature (including the diversity of organisms, ecosystems, and their associated ecological and evolutionary processes) to people's quality of life (Díaz et al. 2018, IPBES 2019). In the context of this report and its suggestions to the post-2020 Global Biodiversity Framework, *nature's contributions to people* and *nature's benefits to people* are used as synonyms, although "contributions" is preferred because of its more standard meaning in the recent scientific and science-policy literature. Nature's contributions to people includes, and is broader than, ecosystem goods and services, nature's gifts, and other analogous concepts.

We also commend the focus in the Zero Draft, at this high level, on outcomes (results to be achieved) for nature and people, with the actions to tackle the direct and indirect drivers affecting those outcomes addressed through complementary targets to support the high-level goals.

Living nature is multidimensional, spanning biodiversity at all levels from genes to biomes, and its manifold benefits and some detriments to people. It also underpins, in different ways, all the UN Sustainable Development Goals (Wood et al. 2018). Therefore, we commend the focus on different facets of nature (or levels of organization within biodiversity): ecosystems, species and genetic diversity within species, and the ecological interactions among them, each receiving the same level of importance. We demonstrate how these goals cannot be fully achieved in isolation. Rather, each of them contributes synergistically to the achievement of the others. Therefore, condensing the goals into fewer goals, each with more tightly packaged facets and elements, would risk obscuring the multidimensionality of living nature and the complementarity of the outcome goals in achieving the long-term vision of CBD.

While realizing that global goals necessarily need to be as general as possible, we stress the need to specify various aspects of species and ecosystems when setting different goals and targets, because of the extraordinary heterogeneity of nature. For example, there are different considerations for "natural" *versus* "managed" ecosystems[2], or for particular ecosystems or groups of organisms that are highly restricted or vulnerable, or critically important for ecosystem functioning and provision of benefits to people.

We also stress the need to consider all ecosystems under the double perspectives of conserving nature and ensuring the long-term provision of benefits to people. "Natural" ecosystems provide essential benefits to people. For example, large carbon-dense wilderness areas are essential to global climate stability: halting their conversion and loss is essential to protecting nature and to achieving the Paris Climate Agreement. At the same time, "managed" ecosystems should not be considered as "lost for nature"; they provide important opportunities for nature conservation and nature's contributions to people. We will not be able to bend the curve on biodiversity loss without improving the condition of "managed" landscapes and seascapes. They are critically important to human wellbeing for the provision of material goods, in many cases through pollination, pest control, and other essential benefits that underpin food and nutritional security. We recommend avoiding false dichotomies, e.g. "natural ecosystems for nature" *versus* "managed ecosystems for people". We will not be able to halt the decline of nature and its contributions to people without concerted efforts to rebuild biodiversity in "managed" landscapes.

In terms of timelines we note it may be most useful to identify a "reference year" for measurement, rather than a baseline year or state that is "desirable". Thus 2020 is a logical reference starting year, with the setting of goals for both 2030 and 2050. The year 2050 gives time to achieve an ambitious enough vision; but having milestones by 2030 allows for good tracking of progress. Another important consideration when setting timelines for the different goals and derived targets is the existence of time lags in the response of different organisms and ecosystems to different actions. Lack of response may mean that the action is ineffective or, alternatively, that the system requires more time to show a response. For example, some forests require more than a century to achieve a late-successional stage (Watts et al. 2020).

The joint consideration of the "ambition tables" developed for these goals (Tables 1-4) provides an overview of the need for high ambition from the start, to succeed in delivering on the Convention's vision for 2050 of "living in harmony with nature". Lower levels of ambition would deliver inadequate outcomes, including loss of "natural" and critical ecosystems, species extinction and reduced abundance and productivity of many species important for the provision of nature's contributions to people (NCP), loss of genetic diversity, and reduced benefits transfer from nature to

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[2] See section ***"Natural" ecosystems and "managed" ecosystems*** (p. 10) for our usage of these terms.

Preamble to individual goal sections

In the sections below we identify key elements of each goal and synthesize the scientific and technical justification for these. We assess the goals as proposed in the Zero Draft as well as amendments proposed at the 2nd meeting of the Open-Ended Working Group on the post 2020 Global Biodiversity Framework, in Rome, February 2020. Based on current available science, these key elements are needed to ensure that the goals are the most scientifically defensible, actionable, and achievable. However, recognizing that it may be impractical to include all elements in the final text of the goals adopted by the Parties, **these elements could be incorporated in the related parts of the framework for monitoring progress and/or reflected in action-oriented targets**. In support of the need for quantitative targets supporting each goal, we provide a summary "ambition table" intended to help CBD Parties and supporters unite around the commitment needed to deliver the CBD's 2050 Vision through these outcome goals.

2. Key elements concerning Ecosystems (Goal a)

Zero Draft - (a) No net loss by 2030 in the area and integrity of freshwater, marine and terrestrial ecosystems, and increases of at least [20%] by 2050, ensuring ecosystem resilience

Net loss

No-Net-Loss (NNL) policies have existed for decades, but examples of successful outcomes are rare (May et al. 2017, zu Ermgassen et al. 2019). We suggest (1) ensuring the wording and explanation of any net outcome goal clarifies critical elements in such a way that avoids potential misinterpretations that would lead to undesirable outcomes or perverse incentives (see below); and (2) drawing from the experience of NNL policies to ensure that mechanisms to achieve NNL are well-designed, well-implemented, and soundly governed.

The "net" component of NNL implies that gains in area and integrity of ecosystems can counterbalance losses (Maron et al. 2018), and the timeline in the CBD goals suggests that (net) gains can be realized by 2030-2050, which implies that the loss of irreplaceable ecosystems is allowed to happen. A large literature demonstrates important limitations in our ability to re-create ecosystems, due to both long time lags in ecosystem recovery and restoration failure (reviewed in e.g. Benayas et al. 2009, McCrackin et al. 2016, Moreno-Mateos et al. 2017, Jones et al. 2018). We suggest explicit recognition of these limits to replaceability, including the consideration of time lags when calculating "net" achievement.

We note the relevance of the UNCCD "Land Degradation Neutrality" (LDN) mechanism, which is based on the NNL concept (Cowie et al. 2018) and which grapples with many of the issues discussed here.

Critical ecosystems

Ecosystems for which evidence of potential for restoration or replacement is lacking should be considered "no loss" ecosystems, because gains could not counterbalance losses of such ecosystems. NNL will almost certainly lead to inadequate outcomes for those ecosystems: for example, the inability to compensate for losses in some ecosystems, or the long time lags involved in such compensation, may lead to collapse of these ecosystems or have large impacts on planetary functions. These critical ecosystems may already be rare (small spatial area, e.g. specific island ecosystems), vulnerable (substantial habitat loss, intrinsically rare, or containing particularly important biotic assemblages, e.g. the Atlantic forest), or so important for planetary function, that any further decline in their area or integrity will lead to either a collapse/extinction of the ecosystem or of the function it provides, e.g. mangrove and seagrass ecosystems (Bland et al. 2017 and 2018, Hughes et al. 2018). For these critical ecosystems, an immediate "no loss" goal starting in 2020 should apply, complemented by increases in area and condition essential to mitigate their risk of collapse or loss of function. To support this, an inventory or catalogue of no loss critical ecosystems should be developed at national and global levels.

Reference year

Specifying a reference date for this goal is necessary to avoid perverse outcomes. The phrasing of the draft goal is ambiguous on whether this goal will be assessed based on the trend in either year, or based on a comparison with 2020. Expressing the goal as outcomes that should occur "by 2030", without a reference date could allow very heterogeneous application using whatever past or future dates that are the least constraining. This could permit a further decade of inaction and unmitigated loss of ecosystem area and integrity. **Such issues could be avoided by defining the 2030 outcome relative to the current (2020) state** (Mace et al. 2018, Leclere et al. 2020). This specification would ensure that no further loss is happening in the 2020-2030 period.

Area and integrity

Area and integrity are complementary components of the goal. Ample scientific evidence demonstrates the need for conserving both area and integrity of ecosystems to safeguard biodiversity (e.g. Newmark 2008). Area and integrity cannot be substituted and should therefore not be captured in one integrated indicator to measure progress towards achieving the goal. This critical issue can be addressed by specifying both “area and integrity” in the No-Net-Loss statement because both are underlying conditions for meeting the other goals on species, genetic diversity and nature’s contributions to people, as well as for safeguarding ecosystems.

Integrity

A clear and quantifiable definition of ecosystem integrity is necessary to ensure inclusion of all critical components required to achieve the envisioned outcome. Ecosystem integrity includes a broad range of ecosystem properties, such as diversity, structure, function and health compared to with native species and very low human impact. Ecosystem integrity is usually defined to include functional, compositional, and structural/spatial components (Andreasen et al. 2001, Wurtzebach and Schultz 2016, Watson et al. 2020). As such, the use of “integrity” in this goal ensures that it includes all important aspects of ecosystems without naming each of its individual components. For example, alternative specifications of the goal mentioning both integrity and connectivity are unnecessary because common definitions of integrity include connectivity. Similarly, the addition of other terms such as resilience is unnecessary.

Restoring area and integrity

Multiple sources of evidence point to the need for a net increase in ecosystem area and integrity to ensure resilience of critical ecosystems and to support the achievement of the other goals of the GBF (Dinerstein et al. 2017, Mace et al. 2018, Watson et al. 2018, Griscom et al. 2017). The increase in area and integrity of “natural”[3] ecosystems can be achieved both through restoration of “managed” ecosystems back into a “natural” state (increases area first and then, over a longer time frame, also integrity) and by the restoration of degraded “natural” ecosystems to a higher level of integrity (but no increase in area). The rehabilitation of “managed” ecosystems also delivers gains for biodiversity and people but these actions cannot substitute for achieving the goal of increasing the integrity of “natural” systems.

A substantial increase in overall “natural” ecosystem area and integrity could reduce the global extinction debt[4] in terrestrial systems by up to 70% (Strassburg et al. under review), and protecting (i.e. removing human pressures) 20% of marine ecosystem area could achieve 90% of the maximum potential biodiversity benefits (Sala et al. under review). Current evidence indicates that substantial recovery (i.e. 50–90%) of marine life is possible by 2050, if relevant pressure alleviation and recovery measures are implemented (Duarte et al. 2020). The increase in overall “natural” ecosystem area and integrity will also buffer against loss of ecological interactions that can be crucial to assure ecosystem functions, given that

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[3] For definitions see section ***“Natural” ecosystems and “managed” ecosystems.***

[4] Extinction debt refers to situations in which, following habitat loss, the threshold condition for survival is no longer met for some species, but these species have not yet gone extinct because of the time delay in their response to environmental change (Tilman et al. 1994, Hanski and Ovaskainen 2002).

these interactions may go extinct well before species go extinct (Valiente-Banuet et al. 2015). Delaying this increase in area and integrity means that more of these species and their interactions will go extinct. The stated ambition of the contribution to the Paris Climate Agreement also requires substantial increases in "natural" ecosystem area. In the face of increasing competition for land resources, the 20% increase in "natural" ecosystem area, though feasible, requires transformative change in consumption patterns and agricultural management.

Integrated planning

Scientific evidence demonstrates that conservation and restoration outcomes strongly depend on location (Pouzols et al. 2014, Weeks et al. 2015, Venter et al. 2016, Strassburg et al. under review, Sala et al. under review). If carefully targeted, small area gains can make large positive contributions to biodiversity outcomes (Pollock et al. 2017). If not carefully targeted, the benefit of gain in ecosystem area on species, genetic diversity, and nature's contributions to people can be small. NNL can even lead to a loss in these components if sub-optimal locations are used for compensation (Maron et al. 2018 and 2020). Integrated planning is therefore necessary for prioritizing locations for conservation, restoration, and human use. Such planning should also be forward-looking in response to future scenarios.

Ecosystem

The No-Net-Loss mechanism requires replacement of lost ecosystems by ecosystems of the same type. Substitution of one ecosystem with an ecosystem of another type leads to exchanges of gains and losses between ecosystems whose differences mean that they are not truly substitutable. Furthermore, some ecosystems are simply impossible to substitute because they are unique and/or cannot be restored (see Critical ecosystems section). This can be dealt with by providing the NNL goal with a definition of ecosystems that captures unique assemblages that, if removed, could not be replaced by restoration in another area. However, too-narrowly defined ecosystems covering too small areas would jeopardize the implementation of the mechanism. We therefore recommend the consensus definition of an ecosystem as "*a distinct assemblage of interacting organisms that occurs in a clearly defined geophysical environment, which differs from adjacent/other ecosystems*".

"Natural" ecosystems and "managed" ecosystems

Noting the relevance of all ecosystems to biodiversity and nature's contributions to people, the differences in characteristics of ecosystems require different actions in ecosystems that are predominantly "natural" compared to those that are predominantly "managed". The world contains a gradient from wilderness areas with very little human influence to strongly converted, used and/or managed ecosystems. "Natural" ecosystems are typically defined as those whose species composition is predominantly determined by the extant climatic-geophysical environment (while acknowledging a backdrop of climate change). We explicitly note that such "natural" ecosystems do not necessarily exclude human habitation, management and use of resources (Boivin et al. 2016, Malhi et al. 2016, Maezumi et al. 2018, Levis et al. 2020). We also stress that not all "natural" ecosystems qualify as "wilderness" (in the sense of e.g. Watson et al. 2018); many, perhaps most, have lost their integrity to some degree and/or are at various stages of secondary succession. The goal of net gain of both area and integrity applies only to these predominantly "natural" ecosystems because gain in their area will by definition have to come from "managed" ecosystems. "Managed" ecosystems include all of those predominantly determined by human use; their rehabilitation can be achieved through two different mechanisms: the re-introduction of native habitat elements into predominantly non-native landscapes and the diversification or more sustainable management of the "managed" ecosystem itself. These interventions can support "natural" ecosystems by enhancing the connectivity between "natural" ecosystems. Furthermore, rehabilitation of "managed" ecosystems can increase their functionality and capacity to provide nature's contributions to people without transitioning into "natural" states. "Managed" ecosystems should therefore show no net loss of integrity and preferably a net gain in integrity (IPBES 2018; see Goal d section).

Proposed reformulation of Goal a statement

Critical elements:

- 2020 and 2030.
- Ensure achieving no loss of critical ecosystems, i.e., ecosystems that are rare, vulnerable or essential for planetary function.
- Ensure like-for-like compensation by having a clear ecosystem definition and no substitution between different ecosystems.
- Aim for no net loss of both area and integrity in “natural” ecosystems and no net loss of integrity of “managed” ecosystems by 2030. Integrity of “managed” areas should be increased by 2050 to ensure recovery of nature’s contributions to people.
- Maintain a restoration ambition as part of the goals (“net gain in area and integrity”) with implementation through integrated planning to optimize benefits for nature and people.

Proposed reformulation of goal statement (modifications from Zero Draft goal in red):

> *No additional loss of critical ecosystems. No net loss by 2030 in both the area and integrity of all “natural” ecosystems compared to 2020, and increases of at least 20% in the area and integrity of “natural” ecosystems by 2050. No net loss of integrity of “managed” ecosystems, and net gain by 2050.*

Table 1 "Ambition table" for Goal a, intended to clarify the ambition needed to achieve the goal elements presented in the preceding text and that are scientifically necessary to achieve the 2030 outcome goals and the 2050 Vision. NCP = nature's contributions to people.

Goal	**Ambition**	**Alignment to 2050 Vision**	**Benefit/Risk for biodiversity and NCP**
No net loss between 2020 and 2030 (any loss balanced by restoration)			
Without safeguards to avoid substitution between ecosystems	**Low ambition**, improvement over current trends needed	**Very poor**	Insufficient to prevent perverse outcomes that negatively affect biodiversity and NCP
With safeguards avoiding substitution between ecosystems	**Medium ambition**, requires dedicated action to balance losses	**Good**	Possible to largely meet goal, but still lose many critical ecosystems and related key NCP
With safeguards avoiding substitution between ecosystems and a no loss of critical ecosystems	**High ambition,** requires dedicated action to balance losses and expand full protection to all critical ecosystems	**Very good**	Necessary to prevent loss of critical ecosystems and maintain NCP provision. Some residual loss of species and genetic diversity possible
Net gain by 2050 *(net gain of area and integrity of ecosystems through retention and restoration)*			
0% net gain	**Low ambition**, improvements over current trends needed	**Poor**	Bending the curve for goals b, c and d cannot be achieved without net gain
20% net gain of area and integrity (not targeted)	**High ambition**, transformative change needed to make land and sea available to achieve area expansion of "natural" ecosystems	**Good**	Will strongly contribute to achieving goals b, c and d but there is high variation in the contribution depending on the targeted areas and ecosystems
20% net gain of area and integrity targeted through integrated planning	**Very high ambition**, requires transformative change and adoption of integrated land and sea use planning. Integrated planning helps to maximize outcomes and reduces overall costs	**Very good**	Secures optimal outcomes towards achieving goals b, c and d

3. Key elements concerning Species (Goal b)

Zero Draft - (b) The percentage of species threatened with extinction is reduced by [X%] and the abundance of species has increased on average by [X%] by 2030 and by [X%] by 2050.

Percentage of threatened species

Aiming solely to reduce the percentage of threatened species in a fixed amount of time (by 2030 or 2050) would lead to poor outcomes as some species (e.g. those with "fast" life cycles) would inevitably be prioritized over others. Different species have very different life histories, which determine their capacity to recover and the time it takes to recover once threats are removed or reversed. Species with a "fast" life history (in general, smaller species) can recover more quickly, while those with a "slow" life history (e.g. large mammals, birds, and long-lived trees) may take several decades to respond to conservation interventions (Cardillo et al. 2005, Davidson et al. 2017). As a consequence, Goal b as written in the Zero Draft could shift conservation focus exclusively to species with "fast" life histories with greater capacity to recover in a very short time frame, unless the goal is articulated in such a way that it ensures that this would not be the case. This could be addressed by including a 2050 target and by addressing extinction risk (see below).

Shifting focus from threatened species to extinction risk

While reducing the proportion of species at the highest risk of extinction (threatened species) is useful to prioritize conservation efforts in the short term, the longer-term goal should be to reduce extinction risk across all species. Extinction risk is a measure of the likelihood that a species will go extinct. The measure takes into account differences in species' life histories, the threats facing them and their susceptibility to extinction. Extinction risk is a continuous measure from low to high and is generally forward-looking, because it determines future extinction rates. **Threatened species** are those species judged to be at high extinction risk today.

Consideration of extinction rate

As currently written, Goal b from the Zero Draft calls for reducing the **percentage of species threatened with extinction**, which is a reversible loss of biodiversity, but it does not contain language for **halting/avoiding extinctions** or **reducing the rate of species extinctions**, which is necessary to avoid an irreversible loss of species, taxonomic diversity and evolutionary history. Specific language to prevent irreversible losses, i.e. **reducing the rate of extinctions** should be included in the goal.

Evolutionary history

Some species like the reptile tuatara (*Sphenodon punctatus)* or the ginkgo tree (*Ginkgo biloba)*, have no close relatives and have been evolving independently for many millions of years (over 260 million years in the case of the ginkgo, which is the only representative of its order). The loss of such species would imply a disproportionate loss of unique evolutionary history. **If the loss of some species seems unavoidable, then conservation interventions should prioritize evolutionarily distinct species**.

Abundance

The concept of abundance is important to address shifts in community composition, e.g. local population declines in particular groups of species such as pollinating insects (Potts et al. 2016) **or farmland birds** (Schipper et al. 2016, Gregory et al. 2019)**.** These changes affect ecosystem integrity as expressed in Goal a, and the long-term delivery of nature's contributions to people (Goal d). Declines of common species, and species supporting important functions (e.g. top predators, large-bodied herbivores, pollinators), even when they are still far from extinction, have been shown to have large effects on ecosystem functioning and societal benefits (Estes et al. 2011, Doughty et al. 2016, Schweiger and Svenning 2019). The loss of ecological interactions has been observed to occur well before, and at faster rate, than species disappearance (Valiente-Banuet et al. 2015).

Furthermore, increases in the abundance of some species can be undesirable and/or costly (e.g. alien and invasive species). For these reasons, a target for increases in total population abundance without qualifying to which species it applies could have unintended and undesirable consequences. These issues could be addressed by modifying the goal on abundance with a focus on species with key functional roles (Ellison 2019, Perino et al. 2019), although the evidence needed to guide this selection is still incomplete. Given this complexity, guiding principles will be needed to establish reference levels of population abundance, considering multiple species roles and behaviours (e.g. dispersal and migration), and the scale at which monitoring, and conservation actions can be implemented.

Rationale for a suggested reformulation of the goal statement

The goal statement in the Zero-Draft proposed two elements: threatened species and abundance. For the reformulation of Goal b (see below), we recommend three related but distinct elements: extinction rates, extinction risk, and abundance. Within an overall long term aspiration to reduce extinction rates to background levels (Rounsevell et al. in press), extinction rates and extinction risk complement one another by representing two aspects of the distribution of extinction risk across species. Extinctions in the near-term are more likely to occur among species at highest risk of extinction today, i.e. the tail of the extinction risk distribution. The remainder of the species have a lower immediate risk of going extinct but contribute to the long-term extinction rate (which is the integral of the extinction risk density function).

Scientific evidence suggests that the recent species extinction rate is at least tens to hundreds of times the background rate (Proença and Pereira 2017, Diaz et al. 2019, Humphreys et al. 2019) and that it is likely to be increasing rapidly (Barnosky et al. 2014). At the same time evidence shows that species extinctions would have been 2-4 times higher without conservation action in recent times which indicates that conservation action can reduce extinction rate (Butchart et al. 2018, Bolam et al. 2020). Therefore, a plausible goal for extinction rates is to reduce them progressively in 2030 through 2050, assuming that it is not feasible to return them to background levels by 2050.

This proposal addresses the potential future loss of evolutionary history by qualifying that the reduction in extinction rate should be well distributed across the Tree of Life[5], in other words it should avoid the entire loss of a branch (genus or family) of the Tree of Life. In addition to reducing extinction rates, setting a goal to shift the distribution of extinction risk across species to overall lower risk levels would translate into reduced extinction rates over a longer time frame, post-2050. Both extinction rates and extinction risks can now be modelled using increasingly sophisticated approaches that will compensate for the difficulties in measuring them directly (Tedesco et al. 2014, Rosa et al. 2020), although it is critical that monitoring efforts continue and are increased, to be able to track changes in extinction risk and document possible extinctions. Finally, by setting a goal for the recovery of population abundance and distributional extent of "X%" of species (the variable quantity in the goal formulation), this proposal aims to address local biodiversity losses that are important for ecosystems' integrity and that would not be addressed by focusing only on globally threatened species. This is necessary to maintain local ecosystem functioning across ecosystems and geographic regions, within-species genetic diversity, species evolutionary potential and adaptive capacity.

Note on the relationship between proposed Goal b, and Goals a and c

The sub-components of proposed Goal b are complementary and synergistic, as envisaged in Article 2 of the Convention Text. In addressing the local abundance of functional groups, there is a clear link to the integrity of ecosystems included in Goal a. Recognizing this would suggest what the most significant key functions might be different in different contexts. Measuring the loss of species in relation to the evolutionary history they represent provides a link to the loss of genetic diversity in Goal c. Recovering natural population abundances across the entire distribution of a species helps to maintain and eventually enhance within-species genetic diversity, as called for in Goal c.

Proposed reformulation of Goal b statement

Critical elements of Goal b

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[5] The "Tree of Life" is a working model based on complex mathematical algorithms using genetic information of organisms that describes the evolution of all life, including the relationships between taxa—both living and extinct—and estimates of when in Earth history lineages evolved (Soltis et al. 2019).

- Reduce the rate of extinction progressively.
- Minimize the loss of evolutionary history, recognizing that species are not equal in this respect.
- Focus on threatened species to 2030 to prioritize species needing urgent attention, but for 2050, reduce extinction risk across all species, not just the most threatened.
- Re-establish population abundance within local ecological communities, rather than increasing total population abundance overall, prioritizing species with key functional roles.
- Include a qualitative statement about retention and eventual recovery of a natural distributional extent of species.

These points could be addressed by reformulating the goal statement along the following lines:

Species extinction rate and extinction risk are reduced progressively by 2030 and 2050, across the Tree of Life, and the local abundance and distributional extent of species in key functional groups and threatened species is stabilized by 2030 and recovered by 2050.

OR

Species extinction rate has been reduced by X% from 2020 to 2030 and by Y% from 2030 to 2050 across the Tree of Life; local population abundance and distributional extent of [X% of] species in key functional groups and species threatened with extinction has stabilized by 2030 and on a trajectory to recovery by 2050; extinction risk has been reduced for X% of species by 2050.

Table 2 "Ambition table" for Goal b, intended to clarify the ambition needed to achieve the goal elements presented in the preceding text and that, according to scientific evidence, are necessary to achieve the 2030 intermediate goals and 2050 vision. NCP = nature's contributions to people.

Goal/quantity (2030)	**Ambition**	**Alignment to 2050 Vision**	**Benefit/Risk for biodiversity and NCP**
Extinction rates			
Halt increase (0% change) in extinction rates through 2030 and 2050	Low, but better than business-as-usual	Low	Many species are lost, loss of evolutionary history, degradation and/or collapse of ecosystems and many NCP, before 2050 and/or beyond
Reduction in extinction rates – 10% by 2030, 50% by 2050	High, requires transformative change	Medium	Many species are lost, loss of evolutionary history, degradation of ecosystems and many NCP, before 2050 and/or beyond
90% reduction in extinction rates	Very high, requires **major** transformative change. Likely the upper bound of what is achievable	High, acknowledges that some extinction is inevitable	Some functionally important or phylogenetically distinct species may still be lost, potentially compromising ecosystem function and NCP
Evolutionarily distinct species prioritized	Very high, supplementary to options above	High, supports maintenance of diversity across Tree of Life	Ensures maintenance of evolutionary options. Might de-prioritise and increase risk other species with important functions and NCP
Extinction risk			

Extinction risk is stabilized by 2030 and 2050	Low	Low	Species would continue to go extinct at current very high rates
Extinction risk is reduced for 20% of threatened species by 2030 and for 50% of species by 2050	High - requires increasing investment at least 10x	Medium/Low	Species that can recover quickly would be favoured, as large, long-lived organisms require longer periods to reduce extinction risk
Extinction risk is reduced for 50% (or more) of threatened species by 2030 and for all species by 2050	Very high - requires transformative change, increase in investment > 40x	High	Better spread of outcome across species, but some large, long-lived organisms still compromised
Abundance			
Average species population abundance stabilized, by 2030	Medium to high[6], depending on which species are targeted	Low/Medium	Rare, threatened and functionally important species continue to decline if these declines are compensated by increases of generalist species, resulting in further losses of biodiversity, ecosystem functioning and associated NCP
Species population abundance has increased on average by 10%	High to very high[7], depending on which species are targeted for recovery	Medium	
Population abundance of species in key functional groups stabilized by 2030 and functional role recovered by 2050	High to very high, would require transformative change and intense conservation efforts	Medium/High	Local loss of biodiversity, ecosystem function and NCP if relevant conservation-dependent species are not correctly identified and conserved across their range
Population abundance stabilized by 2030 and functional role recovered by 2050 across the entire distributional range of species	Extremely high	High	None

4. Key elements concerning Genes (Goal c)

By 2030, genetic erosion of all wild and domesticated species is halted and, by 2050, the genetic diversity of populations is restored [to XX%] and their adaptive capacity is safeguarded.

Wild and domesticated species

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[6] If the average stabilization is the result of great effort to stabilize commercially valuable species or species otherwise highly threatened by human activities, even stabilization would not be easy.

[7] If the average stabilization is the result of great effort to stabilize commercially valuable species or species otherwise highly threatened by human activities, even stabilization would not be easy.

Specifying both "wild and domesticated species" in the goal is important as their dynamics are very different, and ecosystem integrity and provision of nature's contributions to people depend profoundly on both. The genetic diversity of wild species provides the variation essential to maintain ecosystem stability and ensure benefits to people, and supports species survival and adaptation, linking explicitly to ecosystem and species Goals a and b. Domesticated species include all components of agrobiodiversity (crops and livestock). It also includes their wild relatives, as they are potentially a part of the crop and breed gene-pool. Genetic variation across the gene-pool is necessary to sustain food and nutrition security and production systems by providing genetic materials to cope with pests and disease, changing environmental conditions and to enable adaptation to climate change, linking explicitly to goals d and e.

It is important to clarify that it is **the genetic diversity within wild species of all plants, animals and microbial groups and domesticated species** that matters and not just the percentage of species that is targeted.

Targeting explicitly 90% for wild species would mean that the goal could be achieved while ignoring up to 10% of all species. Thus, all species should be targeted. For crop species, it has been previously argued (UNEP 2002) that conserving at least 70% of the genetic diversity of a crop is a reasonable target to achieve for most crop species in a relatively small sample, provided that a scientifically sound sampling strategy is applied (Marshall and Brown 1975, Brown and Hardner 2000, Lawrence 2002). It is also most probable that for major crops more than 90% may already have been conserved in gene banks, although we do not have concrete scientific evidence for this. However, only a negligible amount of genetic diversity is conserved in gene banks for crop wild relatives (Castañeda-Álvarez et al. 2016), minor crops (Padulosi et al. 2001), and wild species (Maunder et al. 2001). As few as 3% of species are sufficiently safeguarded with regard both to conservation in repositories (*ex situ*) and in the wild (*in situ*) (Khoury et al. 2019a), and there is inadequate genetic diversity (especially for wild relatives) preserved in repositories for most species (Maunder et al. 2001, FAO 2014, Castañeda-Álvarez et al. 2016, Griffith et al. 2017, Mounce et al. 2017, Dohle et al. 2019, Hoban et al. 2019). For livestock species and breeds, there is much less diversity that is adequately conserved due to the lack of *ex situ* repositories. It is very important that the genetic diversity be conserved within wild and on-farm populations of livestock and crops to allow the process of natural selection and evolution to continue (see next section) (Jarvis et al. 2008, Vincent et al. 2019) and be backed up in *ex situ* repositories (Castañeda-Álvarez et al. 2016, Mounce et al. 2017) in order to halt human-induced loss of genetic diversity (i.e. genetic erosion). It is important to specify **human-induced genetic erosion** because of the background natural genetic erosion that is beyond our control. Special mention should be made of oceanic islands where island populations have large numbers of endemic species and thus unique genetic heritages, meaning that even a single population loss could lead to significant genetic erosion (Whittaker and Fernández-Palacios 2007).

Populations and adaptive potential

Reference to "populations and adaptive potential" in a proposed alternative for the goal is critically important. The population is the key unit at which evolution and adaption take place, and genetic diversity within and among populations is the primary determinant for ensuring resilience and survival of the species. The capacity of populations in the wild and on farm to respond to environmental change and to be resilient depends on the breadth of the genetic diversity and traits contained within the populations that allows them to evolve and adapt to environmental and climatic changes. These traits are often contained in rare alleles, and in combinations of alleles that are easily lost, thus a 90% target may be insufficient to assure their retention. In principle, conserving adaptive potential should therefore apply to the full range of genetic diversity of a given species, but it may be difficult to measure in practice. For domesticated species, adaptive potential may be held by their wild relatives. However, halting human-induced genetic erosion may be difficult to achieve given that major habitat changes are expected in the next decades.

On average

The element "on average" in the Zero Draft goal c, as in Goal b, is problematic for two reasons. First, given that not 50% of the species are threatened, rare or relict species, the connotation "on average" allows in principle to ignore all these species, while it is crucial for the long-term survival of these species that their genetic diversity is maintained – and it is for those species that it is most difficult to achieve. Second, maintenance of genetic diversity is especially a challenge in populations of large, slow-growing organisms with long generation times and with small population sizes (Romiguier et al. 2014). The population size of many small organisms (microbes, invertebrates) tend to be high and loss of genetic diversity may not be an imminent risk, or difficult to quantify. Thus "on average" is too low a target and would seriously undermine ecosystem stability (cfr. large organisms often have a strong cascading impact on ecosystem structure and functioning), raise extinction rates of many species that are currently struggling to cope with the land use changes and harvesting imposed by humans, and put in peril the capacity of agroecosystems to sustain food production, leading to food insecurity. Current scientific evidence shows that genetic diversity is already being eroded globally from habitat and population loss, over-harvest, disease, and extreme events, even for species that are not formally classified as threatened (Garner et al. 2005, Di Battista et al. 2008, Pinsky et al. 2014, Diez-del-Molino et al. 2018, Leigh et al. 2019). One recent study documented 6% global loss of genetic diversity over the past 100 years, and 28% loss for island species (Leigh et al. 2019). On this basis, minimizing genetic losses to less than 25% or even better, 10% of genetic diversity may not only be essential for species and ecosystem function, but also represent meaningful targets to attain. Furthermore, while certain genetic parameters (such as expected heterozygosity) decline relatively slowly with respect to loss in population size, others (especially allelic diversity) decline very rapidly, potentially risking the loss of the "option value" of rare alleles, which may be of beneficial selective value in the future (Hoban et al 2014).

Why there should be a separate Goal focused on genetic diversity

Genetic diversity is critical for long-term resilience of nature and society. In a changing world, it provides the variation that supports species survival and adaptation (Laikre et al. 2020) and maintains ecosystem stability and the provision of nature's contributions to people. Genetic diversity is essential to improve agricultural ecosystems to alleviate poverty and ensure food security in a sustainable fashion (Brown and Hodgkin 2007). This is especially true under increasing climate change, habitat fragmentation, and new pests and diseases, and there are numerous examples of catastrophic loss to societies and economies caused by over-reliance on narrow genetic stocks in agriculture, forestry, and fisheries (Doyle 2016, Bradshaw et al. 2019, IUCN 2020). Monitoring genetic diversity within wild and domesticated species is thus crucial to achieve the 2050 Vision. **Maintaining a separate goal focused specifically on genetic diversity is essential to keep this focus.** Abundance is a key factor in the maintenance of genetic diversity, therefore by conserving sufficient numbers one increases the likelihood of conserving genetic diversity. However, abundance does not always correlate well with genetic diversity. For example, a population of an endangered species might have gone through a strong bottleneck and its current population size may not reflect its current genetic diversity (Laikre et al. 2020). The population might be above a certain critical population size threshold, but may be "living on borrowed time" genetically, and require managed translocation and gene-flow to prevent it losing adaptive resilience. Linking population abundance and genetic diversity in a single goal statement would thus have the disadvantage of missing within-population genetic diversity, essential for continued adaptation to a changing environment. The monitoring of this aspect is becoming increasingly affordable, a tendency that is likely to accelerate in the near future.

Proposed reformulation of Goal c statement

Critical elements:

- Make explicit mention of all wild and domesticated species, including their "wild relatives".
- Make explicit reference to populations and their adaptive capacity.
- Avoid "on average" since this is very likely to set the bar too low.

- Estimating precise quantitative targets for maintaining genetic diversity may be difficult, but current knowledge suggests a minimum of 90% by 2050.

These points could be addressed by reformulating the goal statement along the following lines:
"By 2030, genetic erosion of all wild and domesticated species is halted and, by 2050, the genetic diversity of populations is restored and their adaptive capacity is safeguarded."[8]
Table 3 "Ambition table" for Goal c, intended to clarify the ambition needed to achieve the goal elements presented in the preceding text and that are scientifically necessary to achieve the 2030 intermediate goals and 2050 Vision. NCP = nature's contributions to people.

Options	**Ambition**	**Alignment with 2050 Vision**	**Benefit/Risk to Biodiversity and NCP**
X% Genetic diversity of the species of all major taxonomic groups is maintained			
50% (on average)	Very Low – This may have been already achieved	Low – Allows loss of genetic diversity in the other half and thus reduces functional diversity critical for ecosystem stability and benefits to people	High risk to many threatened species important for NCP and ecosystem integrity. Undermines the potential for evolutionary adaptation for coping with environmental change
75%	Low – Not ambitious enough to retain the diversity necessary to maintain the capacity of species to adapt to changing conditions and other threats	Low	NCP will be highly diminished. Low probability that natural populations of species harbour sufficient diversity, including functional diversity that contributes to ecosystem resilience
90%	High – Would still require very high investment of resources	High –Would sustain species survival in the wild	High level of benefits to the majority of people. Ensures adequate adaptive capacity in populations and species to cope with climate change
100%	Extremely high – Most likely unachievable	Very High – Full breadth of genetic diversity in all species	Species will have full evolutionary capacity to cope with changes in environmental conditions and to maintain ecosystem stability, enabling full realization of potential NCP

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[8] This was one of the suggested reformulations of the goal statement suggested by the second OEWG in Rome.

X% Genetic diversity of domesticated species and their wild relatives is maintained			
50% (average)	Low – For many domesticated species (e.g. major crops) this target may already have been exceeded	Low	This level would reduce NCPs, by not providing the necessary trait variants to cope with changed environmental conditions, ~~(~~and would undermine the potential to respond to pests and diseases
75%	Medium – Not ambitious enough to retain the diversity necessary to maintain the capacity of species to adapt to environmental change and other threats	Low	NCP will be highly diminished Low probability that natural populations of species harbour sufficient diversity, including functional diversity that ensures ecosystem stability and resilience
90%	High — For major crops this will require a concerted action	High	Would provide high level benefits to the majority of people and provide adequate adaptive capacity to cope with climate change
100%	Extremely high – Most likely unachievable	Very High	Maximum benefits from NCP, such as food production and the maintenance of options that depends on species evolutionary capacity

5. Key elements concerning Nature's contributions to people (Goal d)

Zero Draft - (d) Nature provides benefits to people contributing to:

(i) Improvements in nutrition for at least [X million] people by 2030 and [Y million] by 2050;

(ii) Improvements in sustainable access to safe and drinkable water for at least [X million] people, by 2030 and [Y million] by 2050;

(iii) Improvements in resilience to natural disasters for at least [X million] people by 2030 and [Y million] by 2050;

(iv) At least [30%] of efforts to achieve the targets of the Paris Agreement in 2030 and 2050

Importance of explicit consideration of nature's contributions to people in the goals

We recognize the critical importance of a specific goal addressing nature's contributions to people (NCP). NCP embraces a wide range of human-nature interactions, ecosystem goods and services, nature's benefits, nature's gifts and other analogous concepts (IPBES 2019, see footnote on p. 4 for definition)**.** The IPBES Global Assessment (Díaz et al. 2019, IPBES 2019) flags the simultaneous decline of 14 regulating and non-material contributions, including those that underpin material contributions, with a resulting loss of overall ecosystem resilience. Therefore, it should not be assumed that the present level of delivery of nature's contributions to people will be maintained over time. Goal d would benefit from specifying the provision of which NCP need to change to achieve the 2030 Mission and 2050 Vision of "living in harmony with nature". The outcome of nature providing benefits to people should be captured with measures of improvement for all but with special attention to the poor and marginalized people.

<u>Nature's contributions to people and quality of life</u>

Nature's contributions to people provided by both natural and managed landscapes underpin different dimensions of quality of life (MA 2005, Díaz et al. 2018, IPBES 2019). They do so directly; for example, food provision is at the basis of food and nutritional security, regulation of water quality and quantity is at the basis of water security, and the provision of physical and psychological experiences by green spaces and the provision of genetic resources by wild organisms contribute to human health. Nature's contributions to people also underpin quality of life indirectly; for example, scavengers contribute to disease regulation, and pollinators and natural enemies of pests contribute to crop production. However, a good quality of life depends not only on nature-based contributions, but also on a number of anthropogenic assets (Díaz et al. 2015). For example, water security depends on nature's capacity to filter and redistribute water, but also on access to adequate sanitation systems and distribution networks (Vörösmarty et al. 2010). Most of these anthropogenic assets are beyond the objectives and mandate of the CBD; so are many of the components of a good quality of life. Therefore, we suggest that Goal d is formulated in terms of NCP, with a mention of their key role underpinning a good quality of life, and with action targets and tracking of progress being formulated at the level of NCP. The contributions to human quality of life are best tracked in close collaboration and partnership with organizations with a more specific mandate (e.g., nutrition is more within the scope of the UN Food and Agriculture Organization, health within that of the World Health Organization).

<u>Nature's benefits and sustainable use of biodiversity and ecosystems</u>

Nature's capacity to deliver vital contributions to people now and into the future is reliant on the area and integrity of both "natural" and "managed" ecosystems and their constituent species and within-species genetic diversity (Díaz et al. 2018). This means that Goal d can only be achieved by achieving Goals a-c. We recommend the expression of Goal d as an outcome (the desired state of NCP). We also point to the fact that essential to the achievement of such outcome is the sustainable management of biodiversity, which we recommend to mention explicitly in the targets derived from this goal.

"Natural" ecosystems are critical for preserving essential contributions from nature to people. It is estimated that maintaining 50-85% of high-integrity forests (Steffen et al. 2015) as well as the ecosystems with the highest carbon density (e.g., Amazon, Boreal forests) (Lenton et al. 2008 and 2019) is required to ensure climate stability through biological carbon sequestration, and to achieve the land-based mitigation targets under the Paris Agreement. Nature-based solutions[9] (implemented in both "natural" and "managed" ecosystems) can support up to 37% of climate mitigation action required by the Paris Agreement (Griscom et al. 2017, Roe et al. 2019). The preservation of the integrity of marine ecosystems contributes to achieve climate change mitigation and food provision (Sala et al. under review, Hoegh-Guldberg et al. 2019, Costello et al. 2019).

The integrity of "managed" ecosystems is crucial to deliver nature's contributions to people, but with different nuances from "natural" ecosystems. In "managed" ecosystems integrity is enhanced through the increase in the diversity of crop varieties and animal breeds and soil biota (Garibaldi et al. 2019) and the sustainable (minimal-disturbance) management to avoid detrimental impacts on species inhabiting these landscapes, as well as the diversity of bio-structural elements relevant to ecosystem functions, including the proportion and mosaic of native habitats. Restoration of native habitats to a

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[9] Nature-based solutions are defined by the European Commission as *"solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions."* https://ec.europa.eu/research/environment/index.cfm?pg=nbs

minimum of 10-20% at fine scales (1 km^2) within “managed” systems has been proposed as a threshold to support their integrity and delivery of NCP (Garibaldi et al. 2019, Willett et al. 2019).

Regulating the harvest of wild species to sustainable levels is also critical, since 33% of marine exploited species are considered overexploited (FAO 2019) and approximately 15,000 species of the medicinal plant species worldwide are endangered (Schippmann et al. 2006).

Benefit sharing and inter- and intragenerational equity

For most of the dimensions of quality of life, the number of people who can benefit depends not only on nature’s ability to provide the benefit, but also on societies’ ability to manage demand and distribution of nature’s contributions to people, taking into account intergenerational and intragenerational equities. The 2050 Vision of “living in harmony with nature” will be compromised unless goals related to stabilizing/reducing and equally distributing societies’ demands from NCP are also achieved.

Inter- and intragenerational equity are important for ensuring good quality of life for *all* people. Intergenerational equity recognizes that the effects of measures taken today might only be perceived by future generations, and as such is inextricably linked with sustainability.

Intragenerational equity recognizes that additional support could be needed by marginalized and vulnerable groups, including many Indigenous Peoples and local communities, who more directly depend on the use of nature, and whose livelihoods and quality of life are disproportionately impacted by biodiversity loss (Forest Peoples Program 2016, Fernández-Llamazares et al. 2020). Numerous Indigenous peoples and local communities have played an important role as guardians and stewards of genetic, species, and ecosystem diversity (e.g. Garnett et al. 2018, Fa et al. 2020). Their past and present contributions to maintaining these should be fairly and equitably compensated and the continued access to nature’s contributions that underpin their livelihood should be ensured. Nature in urban areas is not evenly accessible to different sectors of society (Jennings 2012 and 2016). The uneven distribution of NCP across regions is also an important factor, as numerous NCP are traded across large distances, resulting in telecoupling (Liu et al. 2013) that may reinforce inequity (Pascual et al. 2017).

While the current notion of “benefit sharing” within the Convention primarily refers to the utilization of genetic resources and associated traditional knowledge (Objective 3), fair and equitable use of nature and its benefits to people should include multiple biological levels (from genetic to ecosystem) and refer to all nature’s contributions to people. We suggest that the mechanisms considered by the CBD to achieve goals for nature and its contributions to people place particular emphasis on both the equitable sharing and the just distribution of all the benefits provided by nature particularly to those whose livelihoods directly depend on nature’s contributions to people. Particularly important are (a) to ensure that biodiversity protection measures do not have perverse effects, such as limiting the sustainable access to nature by local populations; and (b) to ensure that the sharing of benefits expands beyond the sharing of tangible resources derived from commercial use, and includes nature’s contributions to people in general.

Plurality of values in tracking progress

Tracking outcomes and targets related to nature’s contributions to people requires multiple indicators. So far, most indicators used to track global trends in NCP are biophysical, reflecting only the natural component of nature’s contributions to people (e.g. IPBES 2019). By contrast, much of the uptake by business has involved monetary valuation (TEEB 2012). Plural valuation methods are needed to capture the full range of biophysical, economic, social, health and holistic values provided by nature (Pascual et al. 2017). Assessments and valuation of NCP should also consider various future scenarios (Chaplin-Kramer et al. 2019, FABLE 2019).

<u>Proposed reformulation of Goal d statement</u>

Critical elements:

- Focus on the outcome (nature's contributions to people), not on actions (e.g. sustainable management) or quality of life (which results from NCP interacting with other factors outside the CBD's mandate).
- Consider the capacity of both "natural" and "managed" ecosystems to augment, secure and stabilize the provision of multiple NCP. We note that achieving 10-20% of native habitat area in "managed" ecosystems is likely to maximize synergies for people and nature.
- Consider inter- and intragenerational equity in the distribution of benefits.

These points could be addressed by reformulating the goal statement along the following lines:

(d) Nature's contributions to people that are critical for a good quality of life are enhanced and secured by X [timeframe] by:

> *(i)* ***Maintaining nutritious food provisioning and improving nature's contributions underpinning it****,* ***such as pollination, pest control, eutrophication control, erosion control and soil fertility****, which form the basis of nutrition security.*
>
> *(ii)* ***Improving the regulation of water distribution and quality,*** *which contribute to access to safe and drinkable water.*
>
> *(iii)* ***Improving climate change mitigation through ecosystem carbon sequestration****, which is essential to meet the Paris Agreement commitments*
>
> *(iv)* ***Enhancing coastal protection and flood mitigation by ecosystems****, which contribute to resilience to natural disasters.*
>
> *(v)* ***Enhancing the provision of physical and psychological experiences provided by nature in cities****, to contribute to mental and physical health of the world's growing urban population.*

While not in the goal statements, two supporting elements will be needed to achieve Goal d:

- Specific sub-goals or targets will need to be developed for each NCP (e.g. food provision, coastal protection and flood mitigation, climate change mitigation, provision of physical and psychological that support health), specifying what ecosystems and other facets of nature need to be ensured to deliver each of the nature's contributions to people considered. To be successful they will require complementary quality of life targets from relevant responsible institutions (e.g. FAO, UNFCCC, UN Habitat).

- We note that restoration of 10-20% of native habitat area in "managed" ecosystems may be a critical element to augment, secure and stabilize the provision of many of these, and other, NCPs. As such, it may have value as an Action Target, complementing those already considered.

Table 4 “Ambition table” for Goal d, focused on outcomes for different NCP (food provision, broken down into food from domesticated vs. wild species; water regulation; natural hazards protection; climate change mitigation; and contribution to general health). Each benefit (NCP outcome) is evaluated according to which aspects of Goals a, b and/or c contribute to achieving it, and what additional actions are needed in “managed” systems, and how many beneficiaries could be expected at the highest level of ambition. NCP = nature’s contributions to people.

NCP outcome	**Which parts of delivering on Goals a, b and c are most important?**	**What else is needed in “managed” systems?**	**What does ambitious delivery mean for outcome?**
Nutrition from crop production	Maintain species and genetic diversity of domesticated species (c)	More sustainable production in “managed” ecosystems. Restoration to 10-20% native habitat within each 1 km^2 of “managed” ecosystems	Greater nutritional security for 4 billion people, including the 2 billion whom remain hungry (FAO 2019, Willett et al. 2019)
Nutrition from wild species	Species abundance stabilized across functional groups (c); maintain 90% genetic diversity (c)	Reduce fisheries discards, bycatch, damage on seabeds and reefs. Reduce the share of wild species products for non-food purposes. Preserve local food provisioning to limit inequity in the use of wild species	Greater nutritional security for >500 million highly dependent on marine (Selig et al. 2018) and freshwater fisheries and >150 million households harvesting wild meat (Nielsen et al. 2019)
Safe drinking water	Strict no net loss in “natural” systems + 20% net gain (a)	More sustainable production in “managed” ecosystems. Restoration to 10-20% native habitat within each $1km^2$ of “managed” ecosystems	Improved drinking water for ~600 million people currently dependent on untreated sources (WHO 2019, Jeandron et al. 2019)
Natural hazards protection	Strict no net loss in “natural” systems + 20% net gain (a)	Restoration to 10-20% native habitat within each $1km^2$ of “managed” ecosystems	Enhanced resilience for 75-300 million people at risk of coastal storms (Chaplin-Kramer et al. 2019); 1 billion people in floodplains (Di Baldassarre et al. 2013)
Climate	No loss of critical ecosystems (a) if high carbon value is a criterion of “critical’	More sustainable production in “managed” systems. Restoration to achieve 10-20% native habitat (at $1km^2$) in “managed” systems	Meet 37% of Paris commitments (Griscom et al. 2017)
Wellbeing, including health	No net loss (a); no loss of critical ecosystems (a) if cultural value is a criterion of “critical”; species abundance	Restoration to achieve 20-30% of green space in urban areas	Maintain well-being of ~4 billion people relying on herbal medicinal products (Bodeker et al. 2005). 50% of

	of medicinal plants (b)		global population living in urban areas

6. Key elements concerning Access and benefit sharing (Goal e)

Zero Draft - (e) *The benefits, shared fairly and equitably, from the use of genetic resources and associated traditional knowledge have increased by [X] by 2030 and reached [X] by 2050*

General

Due to time, scope and expertise constraints, our working group did not address this critically important goal in depth. Here we point to some general issues that in our view are imperative to consider in the final formulation of Goal e and its derived targets. We recognize that different pathways to achieve a good future for nature and its contributions to people might have different social impacts. For this, Goal e (on benefit sharing) is essential for achieving the 2050 Vision of "living in harmony with nature". Living within biophysical limits is an important shared goal for humanity, but achieving the 2050 Vision can only be accomplished taking into consideration equity and fairness in terms of responsibilities and rewards between peoples and places and between current and future generations.

7. Annexes

The annexes contain extended rationale, evidence and references concerning each of the goals.

- Annex 7.1 Extra material regarding Ecosystems (Goal a)
- Annex 7.2 Extra material regarding Species (Goal b)
- Annex 7.3 Extra material regarding Genes (Goal c)
- Annex 7.4 Extra material regarding Nature's contributions to people (Goal d)

ANNEX 7.1 Supporting material regarding Ecosystems (Goal a)

No Net loss:
An extensive literature documents the risk involved with NNL policies, mostly in the context of biodiversity offsetting (zu Ermgassen et al. 2019, May et al. 2017, Bull and Strange 2018). In practice, most biodiversity offsets have required gains to counterbalance losses for a narrow range of impact types or causes, and have only aimed for NNL relative to a counterfactual scenario rather than requiring absolute NNL outcomes (Maron et al. 2018). This means that goals of NNL have usually only been relative to a no-intervention scenario, that is typically an ongoing decline; i.e., NNL does not mean that declines are actually stopped). Despite well-established best-practice principles (BBOP 2009, IUCN 2016), many factors contribute to poor outcomes from such policies (reviewed in Maron et al. 2016 and 2018). These include inappropriate use of declining counterfactual scenarios against which to achieve NNL, inadequate or infeasible requirements for restoration actions to counterbalance losses, allowing substitution of one biodiversity feature or ecosystem type for another, failure to account for leakage, perverse incentives built into policy design, poor implementation, and limited oversight and reporting.

We further recommend that the CBD takes stock of the implementation of the UNCCD “Land Degradation Neutrality” (LDN) mechanism, which is based on the NNL concept (Cowie et al. 2018). These mechanisms must align and the LDN conceptual framework grapples with many of the issues discussed herein.

The “net” component of NNL implies that gains in area and integrity of ecosystems can counterbalance losses, and that these gains can be realized by 2030-2050. A large literature (reviewed in e.g. Benayas et al. 2009, McCrackin et al. 2016, Moreno-Mateos et al. 2017, Jones et al. 2019) demonstrates limitations in our ability to re-create ecosystems. Although some ecosystems can be restored well (e.g., temperate wetlands, salt marshes and mangroves), many others are either very hard or impossible to restore (e.g., low nutrient grasslands, lowland raised bogs, coral reefs and afroalpine moorlands). Restoration failure (Maron et al. 2012) can occur because of the extinction of the species that originally inhabited the ecosystem, or because restoration methods are unknown, too slow, too small scale, or too expensive (see coral reef restoration literature for examples of all four). Even in situations when restoration is feasible, the full biodiversity benefits are not immediate but accrue as the ecosystem recovers, which can take many decades (Isbell et al. 2019).

Restoration outcomes are still limited and commonly result in ecosystems with lower diversity and functionality than reference undisturbed ones for many decades or centuries (Moreno-Mateos et al. 2012 and 2017, Curran et al. 2014). Therefore, when area losses are compensated by newly restored areas it is unlikely to achieve a net zero goal within the time frame of evaluation. Delaying this increase in area and integrity means that more of these species will go extinct. However, when combined with measures that enhance the integrity of degraded parts of the ecosystem both area and integrity losses can be compensated and such extinction avoided. It is therefore essential to allocate restoration activities strategically (leading to de-fragmentation of the ecosystem) so both area and integrity losses can be compensated in a way that minimizes risks for extinction during the restoration period. The complexity and costs of proper compensation that retains both area and integrity indicates that ecosystem restoration cannot be used to replace protection because protection provides increased conservation outcomes, at lower costs, without the time delay required for restoration (Jones et al. 2018). Compensation of unavoidable losses should therefore be done with great care and where protection is possible this should be given priority. Note that while protection and prevention of losses is critically important, compensation of losses with protection of existing ecosystems is not valid under the NNL mechanism proposed as part of Goal a – such an approach would lock in continued biodiversity declines (Maron et al. 2018).

Many have argued for a goal based on the fraction of the Earth’s surface occupied by “natural” ecosystems, such as “Half Earth”, implying the conservation of “natural” ecosystems on 50% of the Earth surface (Wilson et al. 2016, Dinerstein et al. 2019). To what extent does such a goal − described in terms of absolute outcome states of ecosystem extent− differ from the NNL and net gain (of e.g. 20% increase of “natural” ecosystems) goal that is framed relative to current extent of ecosystems? In practice, these alternative formulations of the goal may reach a similar outcome. The remaining extent of terrestrial “natural” ecosystems on Earth is approximately 50% of the Earth land area. However, depending on the integrity threshold used to denominate “natural” ecosystems, this can be higher or lower by a considerable margin (Watson et al. 2016). Implementation of a NNL goal in combination with a net gain ambition of 20% to restore those areas that have low ecosystem integrity could achieve a state where “natural” ecosystems with an improved integrity cover about 50% of Earth’s terrestrial area (Maron et al. 2020). A net gain in area is needed for many “critical” ecosystems as well as for “natural” ecosystems within managed landscapes (see goal d). Therefore, a strictly implemented NNL goal, supplemented with a net gain ambition, could allow for achieving the minimum conservation requirements based on recent analyses (Allan et al. 2019) - if appropriate spatial prioritisation and safeguards are set in place, as described herein.

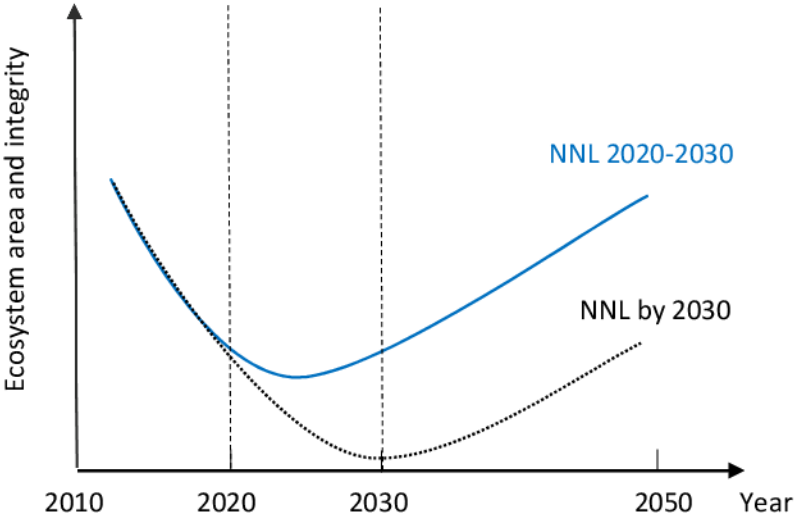
Critical ecosystems:

We propose a “no loss” goal for those ecosystems that are already rare (small spatial area), vulnerable (high amounts of habitat loss, or intrinsically rare, or containing particularly important biotic assemblages), or so important for functioning of other ecosystems or the broader earth system (e.g., high-carbon ecosystems), that any further loss will lead to either a collapse/extinction of the ecosystem or its function. These areas need careful designation and agreement. The definition of critical ecosystems may include those listed as threatened on the IUCN Red List of Ecosystems and those that provide especially vital functions and benefits but are particularly vulnerable (and these may be from small to very large scales). Examples of these ecosystems include specific oceanic or habitat island ecosystems (small spatial area), highly vulnerable ecosystems such as the Atlantic Forest and the Western Ghats forest biodiversity hotspot due to high amounts of habitat loss that have brought the remaining area below a viable area to maintain the ecosystem, and coral reefs (Hughes et al. 2018), which will continue to decline rapidly without targeted intervention. Oceanic islands are a prominent case combining high biodiversity and vulnerability (Volkmann et al. 2014, Tershy et al. 2015) (see section on *Diversity of Oceanic Islands* in Annex 7.2 for details). Systems critical for functioning include nitrogen-fixing ecosystems (where the bacterial and fungal associations can be destroyed easily), coastal transition zones such as salt marshes, mangroves, and seagrasses that support unique functions (Levin et al. 2001), and those ecosystems critical for global carbon sequestration (e.g. peatlands) where carbon lost upon degradation cannot simply be regained by restoration in a reasonable time frame. Implementation of the goal requires the establishment of an annex/registry of critical ecosystems maintained at national/global levels to clarify which ecosystems are considered “critical”.

Some of these critical ecosystems may already fall below the viable area or integrity levels. Increases in area and condition will be essential to mitigate the risk of collapse/extinction/loss of function from these systems (Bland et al. 2017 and 2018).

Reference year:

The key CBD time scales extend from 2020 to 2030 (new strategic plan) and then to 2050 (Vision of living in harmony with nature). The current CBD negotiation lacks clarity on whether the whole of the text on goals (as well as targets) relates to year 2030 or 2050, and is also ambiguous on whether this goal will be assessed based on the trend in either year, or based on a comparison with 2020. We argue that the goals to 2050 (with milestone at 2030) provide a good link to the “bending the curve” narrative (Mace et al. 2018; Leclere et al. 2020). Under this detailed analysis, biodiversity declines must halt and habitats must be returned to at least 2020 area and integrity state by 2030, with further gains achieved by 2050 in order to reduce biodiversity losses and turn them into gains.



No net loss of ecosystems in 2030 relative to the 2020 state means that the area and integrity are at least as high in 2030 as in 2020. This statement does not preclude that any loss may continue after 2020, but requires that it be compensated for by 2030. It should be noted that regaining integrity may take longer than regaining area per se due to the long restoration time required. Therefore, degradation of ecosystems needs to be halted and actions that can rapidly increase the integrity of ecosystems (removing disturbances, fragmentation) needs targeting to meet the goal.

The term "baseline" is best avoided for this goal because different groups use this term for very different concepts.

Area and Integrity:

Area and integrity are both important to sustaining ecosystems. A large area of ecosystem in a strongly degraded or fragmented state cannot support ecosystem function, species, genetic diversity or NCPs. The opposite is also true; a high quality ecosystem with insufficient area coverage cannot support full ecosystem function. For example, ecosystems will lose larger species requiring larger home ranges (Newmark 1995) and those sensitive to habitat edge effects (Newmark 2008). Given that both sufficient area and a sufficient level of integrity are essential pre-conditions of resilient ecosystems, the implementation of the no net loss mechanism should not allow for substituting area for integrity or vice versa. Thus, the goal should not allow compensating for the loss of area by rehabilitating the quality of the remaining area. Allowing such substitution could result in ecosystems becoming either too small in area or too low in integrity to be sustained.

Integrity:

Ecosystem integrity needs to be clearly understood so that the implications for implementation, monitoring and reporting for this goal are well defined. The definition of ecosystem integrity includes functional, compositional, and structural components (Andreasen et al. 2001, Dale and Beyeler 2001, Parrish et al. 2003, Wurtzebach and Schultz 2016). The functional component includes ecosystem and evolutionary processes and their resilience in response to disturbance (Wurtzebach and Schultz 2016). The compositional component includes the taxonomic, functional (Petchey et al 2006, Flynn et al. 2009, Cadotte et al. 2011, Asner et al. 2014, Ordoñez et al. 2015, Jetz et al. 2016, Schneider et al. 2017) and phylogenetic diversity (Faith et al. 2004, Helmus 2007a and 2007b, Mishler et al 2014, Laity et al 2015, Faith 2018 and 2019) of all living organisms in the ecosystem, including invertebrates and microbial organisms (Finlay et al. 1997, Covich et al. 1999a and 1999b, van der Heijden et al. 2008, Tedersoo et al.

2020). Such a compositional component also includes the interactions between these organisms and how these interactions shape networks of species interdependencies. The structural component includes spatial configuration, including fragmentation and connectivity (Cowen and Sponaugle 2009, Saura et al. 2018, Damschen et al. 2019, Tabor 2019), as well as vertical and horizontal heterogeneity (Heinz Center 2008). Marine aspects of integrity are discussed in Roberts et al. 2002, Selig et al. 2018, Sala et al. under review.

Management strategies and monitoring efforts have adopted the concept of ecosystem integrity in various forms across a wide range of ecosystems to address biodiversity concerns (Woodley 2010, Brown and Williams 2016). The relevant indicators for measuring and monitoring these components of ecosystem integrity are dependent on the ecosystem under study and, for example, will differ substantially between terrestrial, freshwater and marine ecosystems. The status and trends of some functional, compositional and structural components of ecosystem integrity can currently be monitored over large areas, but the ability to monitor other key components, including indicators of compositional change, is currently limited (Brown and Williams 2016). Because of the difficulty in monitoring key components of integrity, it may be more practical to monitor change in integrity using measures of pressures on ecosystems as a proxy (Beyer et al. 2019, Watson et al. 2020).

An important aspect of the functional component of ecosystem integrity is that it includes natural or historic disturbance regimes, such as fire, and natural environmental variation, as well as the ability of ecosystems to withstand and recover from these perturbations (Wurtzebach and Schultz 2016). Climate change complicates the use of this definition of functional integrity, because shifting species distributions and disturbance interactions may produce novel ecosystems without historical analogs. Furthermore, this definition of functional integrity may be difficult to apply to systems in which restoration to a natural state is not socially acceptable or feasible (Safford et al. 2012).

Restoring area and integrity:

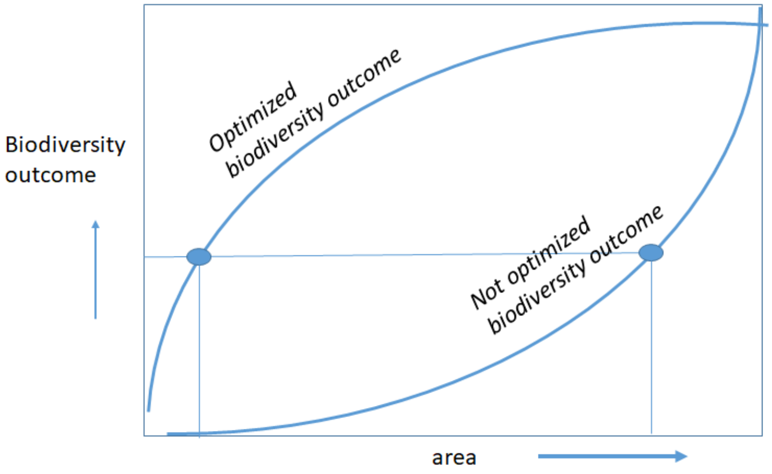
Multiple sources of evidence point to the need for a net increase in ecosystem area and integrity to ensure resilience of critical ecosystems and to support the achievement of the other goals of the GBF (Dinerstein et al. 2017, Mace et al. 2018, Watson et al. 2018). Restoration has emerged as one of the most important strategies to tackle the biodiversity crisis and recover damaged ecosystems. As a proof of that, the United Nations declared 2021-2030 as the Decade of Ecosystem Restoration (United Nations 2019) in alignment with other global strategies, like the New York Declaration on Forests (NYDF Assessment Partners 2019). Restoration outcomes are still limited and commonly result in ecosystems with lower diversity and functionality than reference undisturbed ones for many decades or centuries (Moreno-Mateos et al. 2012 and 2017, Curran et al. 2014). This lack of recovery may be explained by an overall lack of understanding of the recovery process at ecological timescales for any ecosystem. Given the complexity of ecosystems, measuring recovery from human disturbance is an unresolved challenge. Simplified proxies can be used that capture a larger amount of ecosystem complexity which include community structure (including species composition), the structure of species interaction networks, gene flow, adaptive potential or multiple dimensions of stability (Gann et al. 2019, Moreno-Mateos et al. 2020). Reinforcing these new approaches will help make ecosystem restoration a powerful tool to respond to the emerging global requirements to restore the planet.

Simulation studies have shown that converting 20% of terrestrial “managed” ecosystems to “natural” ecosystems could reduce the global terrestrial extinction debt (of 1 million species – IPBES 2019) by up to 70% (Strassburg et al. under review), and delaying this increase in area commits more of these species to extinction. The stated ambition of the contribution to the Paris Climate Accord also requires substantial increases in natural ecosystem area (Griscom et al. 2017). For marine systems it is estimated that enlarging protection (i.e. removing pressures from) for 20% of marine ecosystem area could achieve 90% of the maximum potential biodiversity benefits (Sala et al. under review). Simulation studies have shown that a 20% increase in overall ecosystem area could reduce the global terrestrial extinction debt (of 1 million species – IPBES 2019) by up to 70% (Strassburg et al. under review), and delaying this increase in area commits more of these species to extinction. The stated ambition of the contribution to the Paris Climate Accord also requires substantial increases in natural ecosystem area (Griscom et al. 2017). For marine systems it is estimated that enlarging protection (i.e. removing pressures from) for 20% of marine ecosystem area could achieve 90% of the maximum potential biodiversity benefits (Sala et al. under review). Further, restoration of major components of marine systems fundamental to their integrity (including key species groups, resource populations, ecosystems and environmental parameters) is possible by 2050 if pressures are relieved and appropriate management put in place (Duarte et al. 2020). However, ambitions should be a lot higher if locations for restoration and protection are not chosen in the most effective way (see below), and therefore should be interpreted as a minimum ambition in order to reach the overall 2050 vision.

Despite clear benefits of a 20% increase in “natural” ecosystems, challenges remain given increasing pressures on land resources for multiple objectives and the resulting competition for land resources (Venter et al. 2014, Popp et al. 2017). However, evidence supports the feasibility of achieving a 20% area gain of “natural” ecosystems. This 20% net gain of “natural” ecosystems could be achieved by proactively protecting ecosystems with the highest integrity and then targeting restoration of unproductive or degraded, non-competitive, and former agricultural ecosystems. As these may not be optimal locations for biodiversity a total higher restoration ambition may be required to achieve a similar outcome. Care should be taken that a gain of “natural” ecosystems through restoration does not lead to displacement of food production by import from other countries fostering expansion of food production over natural ecosystems in those countries. Studies document such displacement for forests (Meyfroidt and Lambin 2009) and mangroves (Primavera 1993) for example, a transition that has happened in many countries over the past century. Achieving 20% net gain, would require a transformative change to lowering the total area dedicated to food, feed, biofuel, and fiber production through both sustainable intensification of agriculture and a transformation towards sustainable consumption. Evidence indicates that under these conditions restoration goals could be met (Wolff et al. 2018, Henry et al. 2019, Alexander et al. 2019, Leclere et al. 2020).

Integrated planning:

Scientific evidence demonstrates that conservation and restoration outcomes strongly depend on location (Pouzols et al. 2014, Strassburg et al. under review). If carefully chosen, small area gains can make large positive contributions. If not carefully chosen, the benefit of gain in ecosystem area on species, genetic diversity, and NCPs can be small and no net loss can even lead to a loss in these components if sub-optimal locations are used for compensation. Therefore, strong scientific support points to stimulating integrated ecosystem use planning for prioritizing locations for conservation and restoration and human use. Integrated planning of land and sea use can help to obtain maximum benefits from conservation and restoration and navigate trade-offs between the different goals and other societal objectives. A wide range of available tools support conservation planning (Pouzols et al. 2014, Moore et al. 2016), selecting priority ecosystems for NCPs (Verhagen et al. 2017) and more general approaches to spatial planning of use of land, coastal (Smith et al. 2011) and marine areas (Lester et al. 2018). Evidence shows that such systems can and are adopted in practice (Sinclair et al. 2018).



Strategically increasing effective management of marine systems (ie., increasing area and integrity of marine ecosystems) over an area of 20% of the global ocean would achieve 90% of the maximum potential biodiversity benefits (Sala et al. under review). This effort would be spread as 43% of Economic Exclusive Zones (EEZs) and 5% of the High Seas. Co-benefits of maintaining this area of marine ecosystems in near-natural condition (Goal a) include inclusion of over 80% of the ranges of endangered and critically endangered species (from < 2%, Goal b). Optimizing multiple goals could secure location in a way to ensure no decline in food production (Goal d) AND securing 42% of carbon mitigation benefits from sequestration in deep-sea sediments (Goal d). However, this objective would require managing 62% of the ocean, and thus may inform a longer-term (2050) goal. Another recent study shows that targeting the management across at least 26% of the world's oceans will ensure species and ecosystems integrity outcomes could be achieved (Jones et al. 2020).

Strategic planning is often aimed at obtaining the highest biodiversity outcomes at minimal costs or trade-offs of other land and sea functions. This is in contrast to ambitions that are fully based on designating areas for nature based on moral considerations or easily understandable equal targets across ecoregions. Most well-known are proposals to increase nature conservation until half of Earth's protected. This idea draws on multiple studies and evidence about the distribution and viability of biodiversity features (ecosystem, species, genes) known, empirical data, models, and prioritization algorithms (Locke et al. 2013, Dinerstein et al. 2017 and 2019). It is also an imperative moral, as intraspecies justice - justice for people - should not come at the expense of interspecies justice: the very existence of other species (Cafaro et al. 2017, Kopnina et al. 2018) and it would include to protect indigenous people lands (Dinerstein et al. 2019). The influence of this proposal in global governance is fuelling necessary public attention to the urgent challenges of conserving biodiversity in the Anthropocene and the need for actions but it also have shortcomings to be addressed (Ellis and Mehrabi 2019):

(1) A global scale of land reallocation and environmental governance without precedent. Studies have demonstrated that protecting half of the Earth's surface could directly affect over one billion people (Schleicher et al. 2019) and it will compete with land demands for agriculture having relevant impacts e.g. on food security (Mehrabi et al. 2018). Protecting the adequate parts of Earth, not just the total area protected, is what matters for conserving biodiversity (Pimm et al. 2018, Watson and Venter 2017).

(2) Designating half of Earth's land protected will not, in itself, ensure the conservation of most of Earth's biodiversity but sound management and governance are needed (e.g. Watson et al. 2014, di Marco et al. 2016), as well as adequate investment and funding (Coad et al. 2019), changes in the whole way of living system focusing on drivers of biodiversity loss and how the global economy currently works (e.g. Buscher et al. 2017) and social support that include a wide variety of social concerns ranging from social justice and land sovereignty to the many challenges of fairly, equitably, and effective governance (Bennett et al. 2019).

These concerns indicate the need for careful planning in order to achieve maximum biodiversity outcomes while minimizing trade-offs on other dimensions and value systems.

Ecosystems:

Our definition of ecosystems as a distinct assemblage of interacting organisms that occurs in a clearly defined geophysical environment, that differs from adjacent/other ecosystems is used to implement the compensation mechanism ensuring that a NNL mechanism replaces lost ecosystems with ecosystems of a similar type (often referred to as the like-for-like principle in offsetting programs). The definition chosen builds on typologies of ecosystems developed by Olson et al. (2001: terrestrial), Sayre et al. (2020: terrestrial), Abell et al. (2008: freshwater), Spalding et al. (2007: marine), Watling et al. (2013: deep sea). At national levels, an ecosystem may be assessed within the country and in relation to its ecoregion/province.

Natural ecosystems and managed ecosystems:

Many studies have shown the importance of the integrity of managed ecosystems to support natural ecosystems through providing habitat connectivity (Cowen and Sponaugle 2009) and enlarging the total area available for species that can (partially) use managed ecosystems. Furthermore, evidence shows that sustainable intensification of agro-ecosystems and embedding green infrastructure in cities can increase the integrity of these managed ecosystems supporting natural ecosystems and the delivery of NCPs (Andersson et al. 2014, Seppelt et al. 2016, Rockstrom et al. 2017).

The main factors impacting biodiversity in terms of ecosystem integrity (measured in terms of threats to species) on land have been assessed as overexploitation and agricultural conversion of habitats (Maxwell et al. 2016). “Natural” ecosystems tend to face lower levels of threat from factors such as agriculture, but can still be heavily impacted by overexploitation. In “managed” landscapes threats such as pollution, urban development, invasive alien species, transport and energy production may become more important.

Impacts to marine ecosystems differ from those on land in that people do not occupy ocean space in the same way as in cities and farms; exploitation drives ecosystem health in marine systems more so than by an ocean equivalent of land cover change (IPBES 2019). Improving the extent of healthy marine ecosystems thus happens more through management of human use (ie. reducing key drivers of decline); “natural ecosystems” in the ocean thus align more strongly aligned with “managed ecosystems”. Management actions that reduce pressures and drivers may simultaneously increase the area of near-natural or low-disturbance marine ecosystems (but does not increase the absolute area of the ecosystem as may occur on land), as well as increase their integrity.

ANNEX 7.2 Supporting material regarding Species (Goal b)

Extinction rates

Rationale for our proposal: Several taxa have gone extinct since Aichi Target 12 was set, including Bramble Cay Melomys, Western Black Rhinoceros, Pinta Giant Tortoise and Alagoas Foliage-gleaner. Conservation actions do prevent extinctions. Since 1993 21–32 bird and 7–16 mammal extinctions have been prevented, and the comparable numbers are 9–18 bird and 2–7 mammal extinctions since 2010. Without conservation extinction rates would have been 2.9–4.2 times higher (Bolam et al. 2020). Halting extinction completely by 2030 is not realistic because some extinctions that have been avoided to date have been simply delayed (see Bolam et al. 2020), certain threats will continue to intensify (e.g. climate change and sea level rise) and the life histories of other species suggest that they are on a trajectory to extinction that will be slow or difficult to reverse (Rounsevell et al. in press). Assessments of species extinctions to date have been based on monitoring a small percentage of species (through the IUCN Red List), and documenting when the last individual dies. Extinction records are therefore always delayed, often by many years and cannot take into account species that are not monitored. An element in the goal based on the number of extinctions is therefore highly contingent on the number of species being monitored. Better metrics are the proportion of species extinct in a decade, or alternatively the number of extinctions per million species per year, (Proença and Pereira 2013). Modelling extinctions rates offers an additional basis to guide establishment of milestones/indicators for returning species extinctions to background rates. An extinction rate element should incorporate functional (key roles) and phylogenetic (Tree of Life) dimensions of the diversity of life and not be based on species numbers alone in order to prevent the loss of unique functions and/or phylogenetic history.

Extinction risk

Rationale for our proposal: Given the unavoidable time lags affecting the conservation status of many currently threatened species, we focus the 2030 goal on stabilization and not reduction in the proportion of threatened species. This may be still challenging according to scenarios exploring alternative socio-economic pathways for the 21st century and associated biodiversity trends (Visconti et al. 2016, Pereira et al. 2020). Halving the rate of decline may be more feasible, but requires strong conservation action and reduction of drivers of loss (Visconti et al. 2016, Pereira et al. 2020). The 2050 goal can realistically include the reduction of species extinction risk, because even species with a slow life history and small capacity to recover can respond to conservation action in a time span of three decades (Di Marco et al. 2014).

Distributions and populations are easier to measure and report than extinction risk *per se* (e.g. Rondinini et al. 2011, Ficetola et al. 2015, Tracewski et al. 2016, Brooks et al. 2019, Santini et al. 2019). For this reason, we retain these elements in the 2050 goal.

We propose to calculate X (the unknown in the goal formulation) based on Rounsevell et al. (in press). They propose a goal based on background rates of species extinction, and their model can be used to calculate X so that the resulting extinction rate in a given time window in the future (e.g., 100 years from 2050) is well below the 2050 goal for extinction rate. This method also allows us to lay out the range of ambition that parties could aim towards and give scientific evidence about their feasibility. Similarly, Pereira et al. (2020) assessed extinction rates, changes in distributional extent across species, and changes in mean species abundance both for the 20th century and for three scenarios up to 2050. Results from that study can be used to suggest appropriate values for the quantitative components of the goal above.

<u>Abundance</u>

Functional groups and scale

Rationale for our proposal: The abundance element of this goal is intended to address significant shifts in community composition that have affected e.g. herbivory, top-down control of the ecological community by apex predators, pollination, or cascade effects on food webs (Pereira et al. 2012, Perino et al. 2019). A population might still be viable and therefore not on the brink of extinction, and yet if it has greatly diminished its abundance it might be functionally extinct. Therefore, in order to ensure functional viability, population target levels need to be set high enough so that the population interacts strongly with other species and ecosystem processes (Sanderson 2006) provides the reference level to this goal. However, it has meaning only for certain functional groups of species and at certain spatial scales. In fact, the dependence of ecosystem functioning on certain species can arise at multiple spatial scales, ranging from the local scales at which species interact with one another (Tilman et al. 1997, O'Connor et al. 2017), to the larger landscape scales over which species disperse (Loreau et al. 2003, Isbell et al. 2017, Mori et al. 2018, González et al. 2020). Given this complexity, it is necessary that goals to alter the abundances of species be specified in a manner that accounts for both the functional roles of species and the spatial scales at which ecosystem functioning depends on species and their interactions and dispersal (Perino et al. 2019). The restoration of trophic complexity, and the provision of regulating NCP should be guiding principles that help identifying key functional groups (Perino et al. 2019). The same guiding principles also help in identifying the scale at which to establish reference levels of population density and behaviour (e.g. dispersal and migration) and at which monitoring and conservation actions should be implemented.

<u>Other important considerations</u>

Diversity of oceanic islands

Oceanic islands hold an outstanding number of species and genetic diversity. Although they contribute just 5.3 % of emerged land, they are home to ca. 20% of known species (Courchamp et al. 2014). Due to their vulnerability, they also bear a disproportionate number of the critically endangered species (37%) and the species extinction as a result of the European expansion around the world (61%) (Tershy et al. 2015). Furthermore, since island populations have unique genetic heritages, population losses lead to significant genetic erosion and merit special conservation attention (Volkmann et al. 2014).

Tree of Life in extinction rate element

The Tree of Life evolved from a common ancestor and diversified into millions of species in many distinct lineages from bacteria to turtles to butterflies to palm trees (Hinchcliff et al. 2015, Bar-On et al. 2018), accumulating novel genes and traits over time. The relationships of these lineages across the Tree of Life reflect the evolutionary diversification process. Consequently, all of life is organized hierarchically from individuals nested within populations that are nested within species, which are, in turn nested within lineages of larger and larger size. All members within a lineage share a common ancestor and many of the accumulated genes and characters of that ancestor, which means that all of the species in any given lineage share commonalities in unique characteristics, i.e., genetic potential, function, form, ecosystem function, and other benefits for our life support systems. Losing an entire broad lineage means a loss of that lineage's characteristics and benefits forever. In contrast, losing one of hundreds of similar and barely distinguishable species within a given lineage may be less devastating to our life support systems. The Tree of Life provides an accounting framework for balancing species conservation priorities and highlighting target areas where extinctions should be avoided (Faith 2019). To incorporate phylogenetic diversity into conservation priorities, we recommend no loss of species that do not have multiple close relatives. Close relatives are species that have descended from the same common ancestor within the timespan of the average species age (+/- 1 million years) for the lineage. If the average species age for the lineage is 2 million years, for example, then close relatives would be considered all species that descended from a common ancestor within the last 1-3 million years.

ANNEX 7.3 Supporting material regarding Genes (Goal c)

On average

The average element is too low a target. First, given that not 50% of the species are threatened, rare or relict species, the connotation "on average" allows in principle to ignore all these species, while it is crucial for the long-term survival of these species that their genetic diversity is maintained – and it is for those species that it is most difficult to achieve. Second, maintenance of genetic diversity is especially a challenge in populations of large, slow-growing organisms with long generation times and with small population sizes. (Romiguier et al. 2014). The population size of many small organisms (microbes, invertebrates) tend to be high and loss of genetic diversity may not be an imminent risk, or difficult to quantify. Thus "on average" is too low a target and would seriously undermine ecosystem stability (cfr. large organisms often have a strong cascading impact on ecosystem structure and functioning), raise extinction rates of many species that are currently struggling to cope with the land use changes and harvesting imposed by humans, and put in peril the capacity of agroecosystems to sustain food production, leading to food insecurity.

Wild and domesticated species

We make the argument that goal c needs to make explicit reference to both wild and the domesticated species. There are thousands of non-agricultural species that have economic uses (e.g. timber, food, medicine fish and invertebrate protein that sustains many economically disadvantaged and rural communities) (Willis 2017); are valued as national, cultural or religious symbols; or are ecosystem engineers or keystone species (or support such species e.g. as pollinators). Therefore, genetic diversity in most species supports nature and society. Though there are some gaps in molecular genetic diversity data for taxa and for geographic regions, scientists have assessed genetic diversity within thousands of species over four decades (Pope et al. 2015, Salo and Gustafsson 2016, Perez-Espona and ConGRESS Consortium 2017, Miraldo et al 2017, Torres-Florez 2018, Lawrence et al. 2019). Knowledge gaps are rapidly being filled due to continually decreasing costs of genomic analysis, better data stewardship, and technical advances (Pope et al 2015, Diez-del-Molino et al. 2017, Flanagan et al 2018, Torres-Florez 2018), such that affordable, frequent genetic monitoring can support ambitious targets on genetic erosion.

A recent study by the GEOBON Genetic Composition Working Group (GCWG) emphasizes our recommendation to make explicit that the genetic diversity goal includes all species, especially wild species. They analyzed 114 CBD National Reports from 2014 and 2018 (57 from each year) and found that Reports primarily reported on genetic diversity of agricultural species, much more than wild species of conservation concern, forestry or fishery species, or even crop or breed wild relatives. Numerous country reports recognized the importance of genetic diversity, and also highlighted threats to genetic diversity such as habitat fragmentation, loss of traditional varieties and populations, and climate change. However, reported actions regarding genetic diversity were infrequent and focused primarily on *ex situ* facilities and research agencies. Very few countries reported on genetic diversity monitoring programs or *in situ* conservation genetic interventions. The conclusion was that, in spite of increasing awareness of the importance of genetic diversity, the wording of 2010-2020 Aichi Target 13 emphasizing agricultural species may have influenced, and restricted, the actions taken and reported on, specifically in terms of wild species. Indeed, some countries, goes as far as interpreting the target as concerning only agricultural diversity and seedbanks, and have effectively ignored socio-economic and culturally valuable species (the remaining class of taxa in Target 13).

Genetic diversity within and among the food providing species is also essential for the food system (Khoury et al. 2019b), as it is the raw material that gives crops and livestock resistance to pests and diseases, enabling them to remain productive (Zhu et al. 2000). It also underlies the potential for increasing the nutritional quality of food species (future selection), their tolerance to heat and drought, and their adaptation to changing production challenges and market demands (Gepts 2006, Khoury et al. 2019b).

Further, it is not only extant genetic diversity that is important but also the ability to generate new genetic diversity (primarily via combinations of existing gene-pools, e.g. through adaptive introgression (Stranden et al. 2019) to keep them resilient and able to cope with future change. This requires time and strategic breeding, thus the regions where crops and livestock have persisted for particularly long periods, interacting with warm and cold environments, pests and diseases, and human selection, are especially richly endowed with this novel diversity (Khoury et al. 2019b).

The inclusion of wild relatives is also important. For example, where agriculture overlaps with populations of the wild progenitors of food crops and animal breeds, it has been shown that geneflow between domesticated species and their wild relatives occasionally transpires with the help of insects, wind, and sometimes people (Baltazar et al. 2015, Barbato et al 2015, Bellon et al. 2017). Farmers in these regions recognize that the presence of wild relatives can give their crops renewed vigor. Many farmers also incorporate genetic diversity from outside their communities, planting new cultivars or raising modern breeds alongside their traditional varieties and breeds to encourage the production of offspring that have acquired beneficial attributes from both local and exotic parents (Bellon et al. 2017).

Many global reports (UN 2015, Díaz et al. 2019, FAO 2019) have also recognized the importance of safeguarding the genetic diversity of and within the world's food crops and livestock species. Yet much of the important variation which persists on farms and in wild and semi-wild places in the regions of origin of agriculture continues to lack formal *in situ* conservation support and may therefore be vulnerable to erosion and even extinction, and that traditional and local knowledge of this diversity is likewise being lost (Dulloo et al. 2017, Padulosi et al. 2018, Diaz et al. 2019, FAO 2019; Khoury et al. 2019a). For example, populations of wild sheep and goats in Iran lack the diversity found in domestic gene-pools due to population contraction, fragmentation and overhunting, imperiling their future role as providers of new genetic variation for their domestic counterparts (Alberto et al. 2018).

While *in situ* diversity is constantly changing due to environmental pressures and human preferences, significant losses of food crop and livestock diversity over past decades is a cause for alarm. Further, this diversity is only partially safeguarded in *ex situ* conservation repositories, such as genebank collections, and is therefore not preserved for the long-term, nor readily accessible to plant and animal breeders and other formal agricultural sector actors, and therefore ultimately to other farmers and consumers around the world (Gepts 2006, FAO 2010, Castañeda-Álvarez et al. 2016, Khoury et al. 2019c).

ANNEX 7.4 Supporting material regarding Goal d – Nature's contributions to people

Table 7.4.1 Evidence from the scientific literature pertaining to key elements recommended for Goal d and with regards to **nutrition**: (1) Nature's contributions to people (NCP) and quality of life (including evidence on the population / number of people benefitting from each NCP); (2) Sustainable use of biodiversity and ecosystems (including the rationale for suggested targets); (3) Inter- and intra-generational equity (including between demographic groups and spatially, via telecoupling.

NCP underpinning nutrition improvements	**Benefits and Population benefitting**	**Sustainable use of biodiversity & ecosystems**	**Equity**	**Telecoupling**
Pollination	Scenario modelling of nature's contributions to people under SSPs by 2050 suggests ~5 billion people are at risk of reductions in nutrition due to losses in nature's contribution to pollination. *Chaplin-Kramer et al. 2019*	Dietary health studies flag need to increase consumption of pollination dependent fruits, nuts, and seeds globally. Most relationships reported indicates the more native habitats within working landscapes, the better pollination. *Kremen and Miles 2012* The need of 20% of native habitat area within each 1x1 km of working landscapes emerge as a minimum requisite to support pollination. Review of evidence suggests that 20% represents the maximization of the opportunity-costs vs NCP benefit analysis + qualitative evidence from systematic review. Additionally, crop diversification can enhance pollination. *Garibaldi et al. under review*	Micronutrient deficiencies are three times as likely to occur in areas of highest pollination dependence for vitamin A and iron, suggesting that disruptions in pollination could have serious implications for the accessibility of micronutrients for public health. *Chaplin-Kramer et al. 2014*	Approximately 80% of people worldwide are now residents of countries with net food imports, where calorie imports surpass calorie exports. Pollination is usually embedded in food trade as pollination is essential for many crops. *Porkka et al. 2013, MacDonald et al. 2015*
Pollination	Scenario modelling of nature's contributions to people under SSPs by 2050 suggests ~5 billion people are at risk of reductions in nutrition due to losses in nature's contribution to pollination.	Dietary health studies flag need to increase consumption of pollination dependent fruits, nuts, and seeds globally. Most relationships reported indicates the more native habitats within working landscapes, the better pollination. *Kremen and Miles 2012* The need of 20% of native habitat area within	Micronutrient deficiencies are three times as likely to occur in areas of highest pollination dependence for vitamin A and iron, suggesting that disruptions in pollination could have serious implications for the accessibility of	Approximately 80% of people worldwide are now residents of countries with net food imports, where calorie imports surpass calorie exports. Pollination is usually embedded in food trade as pollination is essential for many crops.

	Chaplin-Kramer et al. 2019	each 1x1 km of working landscapes emerge as a minimum requisite to support pollination. Review of evidence suggests that 20% represents the maximization of the opportunity-costs vs NCP benefit analysis + qualitative evidence from systematic review. Additionally, crop diversification can enhance pollination. *Garibaldi et al. under review*	micronutrients for public health. *Chaplin-Kramer et al. 2014*	*Porkka et al. 2013, MacDonald et al. 2015*
Regulation of detrimental organisms and biological processes	Entire world's population is dependent on crops, of which an estimated 10-40% of global yields are lost to pests each year. *Savary et al. 2019*	The need of 20% of native habitat area within each 1x1 km of working landscapes emerge as a minimum requisite. While landscape effects on pest regulation is variable, the best available evidence shows that this NCP is provided by species with movement thresholds below 1 km. Thus maintaining natural and semi-natural habitat at fine scales is essential to pest control services. The effect of native habitats within working landscapes on regulation of detrimental organisms is largely positive, but its magnitude is variable and there is no information on what minimum of NWL is needed to maintain this process. *Willett et al. 2019, Garibaldi et al. under review* There is also the need to improve the number of corps. Diversifying crops in space and time (rotations) reduces risk of pest population growth to epidemic proportions *Kremen and Miles 2012, Beillouin et al. 2019, Dainese et al. 2019, Renard and Tilman 2019, Rosa-Schleich et. al. 2019*	No evidence was found regarding equity and pest control	Many pests are controlled by "natural enemies" that migrate or are introduced from distant regions or countries. *van Driesche and Bellows 1996, Kleeman et al. 2020*
Formation, protection and decontamination of soils and sediments	Soil erosion has reduced agricultural productivity on 23% of global terrestrial area and affects 3.2 billion people. *IPBES 2018*	Currently, a third of the planet's land is severely degraded and fertile soil is being lost at the rate of 24bn tonnes a year due to intensive farming affecting people's quality of life. There is the need to develop "conservation" agriculture, contour line ploughing, no tillage or sowing directly into a	The impacts of soil loss vary enormously from region to region. Worst affected is sub-Saharan Africa, but poor land management in Europe	In many places around the globe, soil loss is due to human activities (e.g., overgrazing, logging, mining, construction of roads/buildings, agriculture, and recreational facilities) for

		cover crop and mulching bare surfaces in order to decrease soil erosion by over 80%. Crop diversification can also improve soil fertility and water-holding capacity. *Montgomery 2007, Kremen and Miles 2012, United Nations Convention to Combat Desertification 2017*	also accounts for an estimated 970m tonnes of soil loss from erosion each year with impacts on food security. By 2050, sub-Saharan Africa, south Asia, the Middle East and north Africa will face the greatest challenges for food security due to soil loss. *United Nations Convention to Combat Desertification 2017*	producing goods and services for telecoupling (e.g., trade, tourism) or due to telecoupling (e.g. species invasion and pollution transfer) that reduces vegetation and forest cover, which in turn affect soil loss. *Labrière et al. 2015, Referowska-Chodak 2019, Zhao and Hou 2019*
Food and feed (from domesticated species (i))	In 2015, 4 billion people suffered from poor dietary health with 11 million premature deaths per year. Under consumption of a diversity of whole grains, fruits, nuts and seeds, and vegetables are among the top 2-5 top factors cumulatively accounting for 234 million disability-adjusted life-years (DALY's) and 6.7 million premature deaths per year. SDG target 3.4 is to reduce by 33% premature mortality from NCD's through prevention and treatment and target level to halt the rise of obesity. Target 2.2 by 2030 end all forms of malnutrition. 2 billion people lack key micronutrients like iron and vitamin A 155 million children are	Diet-related diseases have become a top risk factor in the global burden of disease. These dietary risks are due to the low consumption of fruits, vegetables, whole grain fibber, nuts, and seeds as well as high intake of sodium, processed meat, red meat, and sugars, including sugar-sweetened beverages. Diabetes, overweight, and obesity have risen in all regions and are projected to rise the fastest in Africa. *GBD Risk Factor Collaborators 2017* To reduce dietary health risk by [80%] by 2030, we need to increase production and consumption of a diversity of crops. This entails to: (1) increase global production/consumption of a diversity fruits by 163%; (2) increase global production/consumption of a diversity of vegetables by 100%; (3) increase global production/consumption of a diversity of legumes by 25%; (4) increase global production/consumption of a diversity of nuts and seeds by 567%; (5) increase global production/consumption of a diversity of whole	Indigenous people internationally frequently suffer greater early mortality rates and poorer health status when compared with non-Indigenous people, with diet-related chronic diseases (including diabetes and cardiovascular disease) being major contributors to the substantial “gap” in health.//Urban food security in developing countries is close tied to food price fluctuations. In poor cities, increases in food prices can rapidly translate into hunger and malnutrition among the urban poor. Urban households with lower socioeconomic status tend	Many food items from domesticated species are now imported from other countries. For example, soybeans were domesticated in China 3,000 years ago, but now more than 85% of soybeans consumed in China are imported from distant countries such as Brazil and the US. *http://www.australianoilseeds.com/data/assets/file/0012/1191/Bob_Hosken-Advances_in_Soybean_Processing_and_Utilisation.pdf, FAO 2020*

	stunted 52 million children are wasted 2 billion adults are overweight and obese 41 million children and growing are overweight or obese. *GBD 2019*	grains by 346%. *Afshin 2019, FAO and WHO 2019, Willett et al. 2019*	to spend more than 70% of their income on food, impacting the availability of funds for education, child care and other activities, live in neighbourhoods where access to healthy food is limited (food deserts), and suffer disproportionately from dietary disease risks https://www.who.int/sustainable-development/cities/health-risks/nutrition-insecurity/en/ *Anderson et al. 2016*	
Food and feed (from domesticated species (ii))	Tens of thousands of edible crops species contribute to food security, averting > 11million premature deaths. *Wang et al. 2019* Loss of diversity, such as phylogenetic and functional diversity, can permanently reduce future options, such as wild species that might be domesticated as new crops and be used for genetic improvement. The pool of genetic variation which underpins food security has declined.	The loss of diversity, including genetic diversity, poses a serious risk to global food security by undermining the resilience of many agricultural systems to threats such as pests, pathogens and climate change. Fewer and fewer varieties and breeds of plants and animals are being cultivated, raised, traded and maintained around the world, despite many local efforts, which include those by indigenous peoples and local communities. By 2016, 559 of the 6,190 domesticated breeds of mammals used for food and agriculture (over 9%) had become extinct and at least 1,000 more are threatened. In addition, many crop wild relatives that are important for long-term food security lack effective protection, and the conservation status of wild relatives of domesticated mammals and birds is worsening. To revert the reductions in the diversity of cultivated plants, crop wild relatives and		Most of the food trade are from domesticated species, although some traded food items are gathered from wild species. *Bharucha and Pretty 2010, Nong 2019*

	IPBES 2019	domesticated breeds so that agroecosystems become more resilient against future climate change, pests and pathogens. Specific actions include promoting sustainable agricultural and agro ecological practices, such as multifunctional landscape planning and cross-sectoral integrated management, that support the conservation of genetic diversity and the associated agricultural biodiversity *IPBES 2019*		
Food from marine fisheries	~500 million people are critically dependent nutritionally, ~3.2 billion people with almost 20 percent of their average per capita intake of animal protein. Omega-3 fatty acids are lacking in more than half of global diets (inversely, achieving global healthy diets would require more than doubling the consumption of omega-3 fatty acids. *Selig et al. 2018, FAO 2018*	A large body of evidence shows that ending overexploitation and rebuilding fish stocks improve marine biodiversity and ecosystem functioning, as well as provide benefits to people by increasing food security and economic profits. *Nielsen et al. 2019, Costello et al 2016, Gaines et al. 2018* Recent studies based on fishing scenarios suggest that rebuilding is feasible within 10 years, and that it helps mitigating the detrimental impacts of climate change on fish resources. *Costello et al 2016, Gaines et al. 2018* Within a decade, rebuilding fish stocks has been successful in some developed countries: the proportion of stocks fished within biologically sustainable levels increased from 53 percent in 2005 to 74 percent in 2016 in the United States of America, and from 27 percent in 2004 to 69 percent in 2015 in Australia. *FAO 2018* To halt overexploitation and rebuild overexploited and depleted stocks to maximum	Promote equitable share of fish resources in a context of worsening status of ecosystems and fisheries overcapacity in developing countries, contrasting with improved fisheries management and stock status in most developed countries. This situation results in part from high international trade of fisheries products from developing countries to developed countries, coupled to international agreements on fishing access in the exclusive economic zone (EEZ) of developing countries. This equity issue is further accentuated by climate change impacts on fish biomass which is likely to experience the largest decrease in the intertropical zone where most developing countries	A substantial portion of marine fishing occurred in distant EEZs. *Carlson et al. under review*

		sustainable yield (MSY) levels, we need to phase out of bottom-impacting and non-selective fishing gears and lower fishing effort by 2050. By 2050, less than 5% of overexploited stocks globally. By 2030, we need to halve the proportion of overexploited stocks.	lie. Ensuring food security from marine fisheries in developing countries is a critical challenge since, despite their lower fish consumption, people in developing countries have a higher share of fish protein in their diets than people in developed countries. *Ye and Gutierrez 2017, FAO 2019, Hicks et al. 2019, Lotze et al. 2019*	
Food from inland fisheries	115 million people from 42 countries are dependent on freshwater fisheries (these are the most vulnerable; the total consumption is obviously likely higher but not as essential because they may have better access to substitutes). Joint analysis of fish consumption and economic status indicates that the world's poor and malnourished rely heavily upon fresh-water fisheries. To account for enormous variation in diet and wealth among nations, an index of nutritional dependency on fisheries based on their proportional role in total animal protein consumption by the population of each country was created.	Modification of inland waterways for alternative uses of freshwater (particularly dams for hydropower and water diversions for human use) negatively impacts the productivity of inland fisheries for food security at local and regional levels. There is the need to protect free running rivers and consider fisheries implications of dam development *Youn et al. 2014*	Inland fishing has increased mainly in Asia and Africa. *Welcomme et al. 2010*	Main inland fisheries provide nutrition to people at distant locations. For example, since 1960s Great Lakes salmonine (i.e. Coho Salmon *Oncorhynchus kisutch*, Chinook Salmon *O. tshawytscha*) has seen movements of fish, money, and information over relatively long distances facilitated by numerous individual and organizational agents. *Carlson et al. 2019*

	Partitioning nutritional dependence among wild-caught freshwater, wild-caught marine, and freshwater aquaculture-derived fish in each nation indicates that wild fish from rivers and lakes provide the equivalent of the total animal protein consumption of 158million people worldwide. Inland fisheries account for 2.36 per cent of animal protein sources. They also provide vitamins, minerals, fatty acids and other micronutrients essential to a healthy diet. *Welcomme et al. 2010, McIntyre et al. 2016, Fluet-Chouinard et al. 2018*			
Food from wild plants	Around one billion people use wild foods in their diet. Forests provide food for some 300 million people in the form of non-timber forest products (NTFPs). *Bharucha and Pretty 2010*	Review of evidence suggests that 20% represents the maximization of the opportunity-costs vs NCP benefit analysis + qualitative evidence from systematic review. The positive role of NWL on habitat creation and maintenance is clear, with evidence supporting 20% as a minimum to be maintained within each 1x1 km of working landscapes. *Garibaldi et al. under review*	Wild food from forests is strongly interlinked in rural communities, especially for the most vulnerable groups. The consumption of wild plants relevant for food is mainly important for communities in Asia and Africa. From a review of wild food consumption in 22 countries of Asia and Africa, the mean use of wild foods (discounting country- or continent-wide aggregates) is 90–100 species per place and	Food from wild plants is often traded in the market and consumed locally by tourists from distant places. For example, there are 120 species of wild food plants in Ethiopia and fruits of *Opuntia ficus indica* and *Borassus aethiopum* are traded in the market for cash. *Georgis et al. 2010*

			community group. *Belcher et al. 2005, Bharucha and Pretty 2010*	
Food from wild animals	Around one billion people use wild foods in their diet. 39% of households, by extrapolation representing ~ 150 million households in the Global South, "harvest" wild meat. On average, wild meat makes up 2% of households' income of which own consumption accounts for 89%. Reliance on wild meat is highest among the poorest households. *Bharucha and Pretty 2010, Nielsen et al. 2019*	Evidence shows that we need to halt and reverse the loss of wild animal species used for food. 32.3% of wild animals that are used for food are high priority for conservation and 63.1% are medium priority. *Khoury et al. 2018*	The wild animals relevant for food that are high priority for conservation are mainly distributed in Asia and Africa. From a review of wild food consumption in 22 countries of Asia and Africa, the mean use of wild foods (discounting country- or continent-wide aggregates) is 90–100 species per place and community group. *Bharucha and Pretty 2010*	Much of the food from wild animals is also traded globally, nationally, or regionally; or consumed locally by tourists from distant places. *Ribas and Poonlaphdecha 2017*

Table 7.4.2 Evidence from the scientific literature pertaining to key elements recommended for Goal d and with regards to **water security**: (1) Nature's contributions to people (NCP) and quality of life (including evidence on the population / number of people benefitting from each NCP); (2) Sustainable use of biodiversity and ecosystems (including the rationale for suggested targets); (3) Inter- and intra-generational equity (including between demographic groups and spatially, via telecoupling.

NCP underpinning water security	**Benefits and Population benefitting**	**Sustainable use of biodiversity & ecosystems**	**Equity**	**Telecoupling**
Regulation of water quality	~600 million people currently dependent on untreated sources (435 million people taking water from unprotected wells and springs; 144 million people collecting untreated	Increased runoff quantity and flow speed due to deforestation, expanding (un-irrigated) cropland, and urbanization. Ecosystem change impact on water regulation, although this evidence is established but incomplete. Comprehensive land-use planning can mitigate	Low-income and minority communities often face disproportionate burdens of exposure to contamination sources and pollution in water, and	Vegetation upstream can reduce runoffs and improve water quality downstream. *Postel et al. 2005*

	surface water from lakes, ponds, rivers and streams). Low quality of drinking water can lead to “waterborne” disease transmission that is the ingestion of infectious agents via contaminated drinking water. *Jeandron et al. 2019, WHO 2019*	some effects of agricultural expansion and its impacts on water quality, such as: planning the pattern and location of agricultural development to preserve biodiversity hotspots; minimizing fragmentation; maximizing the range of ecosystem types preserved; and preserving wetlands and riparian zones that protect surface waters from inputs of nutrients, pesticides, eroded soil and pathogens *IPBES 2019*	associations with race and ethnicity persist even after accounting for differences in income. *Delpla et al. 2015, Switzer et al. 2017, Schaider et al. 2019*	
Regulation of water quantity, location and timing	Overall, there is a positive association between water quantity and health outcomes. Increased water usage for personal hygiene was generally associated with improved trachoma outcomes, while increased water consumption was generally associated with reduced gastrointestinal infection and diarrheal disease and improved growth outcomes. *Stelmach and Clasen 2015, Overbo et al. 2016*	Global river discharge constant over past 50 years, but spatially variable. Groundwater increases in some regions, decreased in others. IPBES GA Chapter 2.3. *IPBES 2019*	An estimated 80% of the world's population faces a high-level water security or water-related biodiversity risk Approximately 40% of the future population of Asia will live in severely water scarce areas. This has also consequences on health since inadequate access to water remains a major public health concern in low- and middle-income countries. *Vörösmarty et al. 2010, Wiberg et al. 2017, Jeandron et al. 2019*	To meet the demand for water, more than 40 countries have constructed over 350 major inter-basin water transfer projects that transfer approximately 570 billion cubic meters of water annually, or approximately 15% of total global annual water withdrawals. *Liu et al. 2016*

Table 7.4.3 Evidence from the scientific literature pertaining to key elements recommended for Goal d and with regards to **resilience against natural hazards**: (1) Nature's contributions to people (NCP) and quality of life (including evidence on the population / number of people benefitting from each NCP); (2) Sustainable use of biodiversity and ecosystems (including the rationale for suggested targets); (3) Inter- and intra-generational equity (including between demographic groups and spatially, via telecoupling.

NCP underpinning natural hazards resilience	**Benefits and Population benefitting**	**Sustainable use of biodiversity & ecosystems**	**Equity**	**Telecoupling**
Coastal protection	300 million people are at risk of increased coastal hazards due to losses in nature's contribution to storm surge/wave attenuation under future SSP scenarios; ~75 million are dependent on coastal protection currently. By 2050, the global population living in the low elevated coastal zones is expected to substantially increase, to more than one billion. *Merkens et al. 2016, Selig et al. 2018, Chaplin-Kramer et al. 2019*	Restoration of marine vegetated habitats and reef-forming species is often considered a way to provide hazards and disaster protection as well as additional ecosystem services to local communities. Mangrove and salt marshes provide hazard and disaster regulation to local communities, by protection from erosion and storm surge. Even narrow bands of mangrove forest along a coastline can provide a meaningful amount of protection. Therefore, it is needed to halt the loss of marine vegetated coastal (mangroves, seagrasses, saltmarshes) and reef-forming (coral reefs, shellfish reefs) species and habitats and restore those degraded *Moberg and Rönnbäck 2003, Gedan et al. 2011, Spalding et al. 2014, Gattuso et al. 2018*	Poor and marginalized populations were more affected by risk of natural hazards. Women are also identified as having decreased resilience to hazards due to income and livelihood disparities in many parts of the world. Additionally, immigrants, minorities, and urban communities also face an increased risk and prolonged losses as a result of complicated evacuation, limited access to lifelines, and lower education constraints which may reduce understanding of warning information. *Cutter et al. 2003, Fordham 2003, Bevacqua et al. 2018*	Fertilizer application in agriculture and yards in distant places can lead to dead zones in coastal areas, reducing mangrove forests and coastal resilience to natural hazards, which in turns affect fertilizer users through reduced sea food production and supply. *Carlson et al. 2019*
Flood mitigation	Flooding is the most prevalent natural disaster, causing more life losses compared to any other natural disaster. 169 million people are exposed to	It is clear that native habitats within working landscapes play a key role in regulating hazards and extreme events but overall, studies do not propose a particular minimum to be maintained.	Very old and very young people tend to be more vulnerable to floods because of their dependency status and	Forests and grasslands upstream can help mitigate flooding downstream, and the impacts of flooding can extend far away through affecting supply chains.

	inland flood hazards annually; nearly 1 billion people live in flood plains and could be expected to benefit from nature's contributions to flood mitigation at some point; under 4°C warming scenarios, flood risk is expected to increase > fourfold, in the most affected countries population exposed increases > 10x (concentrated in Central Europe, South Asia, South America) *Di Baldassarre et al. 2013, Ward et al. 2013, Alfieri et al. 2016, IPBES 2018*	*Moberg and Rönnbäck 2003, Gedan et al. 2011, Spalding et al. 2014, Garibaldi et al. under review*	physical conditions. Special needs populations are more vulnerable to floods since their limited mobility, dependence of care, and reliance on medication and other services are impediments to evacuation. Flood vulnerability is linked to gender status where women disproportionately accept family care responsibilities, both in developed and developing. Race, class, ethnicity and immigration status are additional drivers of flood-related social vulnerability since these may impose cultural and language barriers that affect residential locations in high hazard areas, pre-disaster mitigation, and access to post-disaster resources for recovery. *Rufat et al.2015*	*Gunnell et al. 2019*
Fire prevention	No global figures on people living in the wildland urban interface, where fire risk to people is highest. In the US alone, the WUI areas continue to grow; at least 46 million structures are located in these areas comprising over 70,000 communities and affecting 120 million people.	Leaf litter mass (−24%) and percentage cover of leaf litter (−3%) were significantly lower where reintroduced ecosystem engineers occurred compared to where they were absent, and fire behaviour modelling illustrated this has substantial impacts on flame height and rate of spread. This result has major implications for fire behaviour and management globally wherever ecosystem engineers are now absent as the	The poorest and socially marginalized segments of the population are the most vulnerable to extreme weather events. *Otto et al.* 2017	Fire prevention can reduce impacts elsewhere as it can retain biomass and carbon sequestration to mitigate global climate change. *Ward and Mahowald 2015*

	Manzello et al. 2019	reduced leaf litter volumes where they occur will lead to decreased flame height and rate of fire spread. This illustrates the need to restore the full suite of biodiversity globally. For example, Australia has seen the extinction of 29 of 315 terrestrial mammal species in the last 200 years and several of these species were ecosystem engineers whose fossorial actions may increase the rate of leaf litter breakdown. Thus, their extinction may have altered the rate of litter accumulation and therefore fire ignition potential and rate of spread. *Hayward et al. 2016*		

Table 7.4.4 Evidence from the scientific literature pertaining to key elements recommended for Goal d and with regards to **the Paris Agreement**: (1) Nature's contributions to people (NCP) and quality of life (including evidence on the population / number of people benefitting from each NCP); (2) Sustainable use of biodiversity and ecosystems (including the rationale for suggested targets); (3) Inter- and intra-generational equity (including between demographic groups and spatially, via telecoupling.

NCP for meeting the Paris Agreement	**Benefits and Population benefitting**	**Sustainable use of biodiversity & ecosystems**	**Equity**	**Telecoupling**
Climate change mitigation	Nature could contribute to meeting 25% (by 2030) and 37% (by 2050) of the carbon mitigation commitments of the Paris Accord *Griscom et al. 2017, Roe et al. 2019*	It is estimated that maintaining 50-85% of high-integrity forests as well as the ecosystems highest in carbon density (e.g., Amazon, Boreal forests) is required to ensure carbon sequestration and to achieve the land-based mitigation targets under the Paris Agreement. *Lenton et al. 2008 and 2019, Steffen et al. 2015* More sustainable management practices (e.g., crop diversification, conservation tillage, cover cropping) enhance carbon sequestration by working landscapes *Kremen and Miles 2012*	The poorest and socially marginalized segments of the population are the most vulnerable to climate variability and extremes. This is particularly so in developing countries. Intra-household gender and age differences produce markedly different forms of vulnerability with women, young children and the elderly more likely to suffer. Disabled, unemployed and unmarried people are also more vulnerable to climate change *Otto et al. 2017*	Local carbon sequestration benefits global climate change mitigation. *Carton 2020*

Table 7.4.5 Evidence from the scientific literature pertaining to key elements recommended for Goal d and with regards to **health**: (1) Nature's contributions to people (NCP) and quality of life (including evidence on the population / number of people benefitting from each NCP); (2) Sustainable use of biodiversity and ecosystems (including the rationale for suggested targets); (3) Inter- and intra-generational equity (including between demographic groups and spatially, via telecoupling.

NCP underpinning health	**Benefits and Population benefitting**	**Sustainable use of biodiversity & ecosystems**	**Equity**	**Telecoupling**
Medicinal uses of wild plants	It is estimated that up to four billion people living in the developing world rely on herbal medicinal products as a primary source of healthcare. *Bodeker et al. 2005*	Globally, an estimated of 70,000 species are used for their medicinal, nutritional and aromatic properties and, every year, more than 500 000 tonnes of material from such species are traded. Due to overharvesting and habitat loss, approximately 15 000 species of the global medicinal plant species are now endangered. Therefore, it is needed to halt the extinction of all medicinal plant species by 2030 and recover the populations of the threatened medicinal plant species (20% of medicinal plants) by 2050 *Schippmann et al. 2006, Romanelli et al. 2015*	Green spaces and corresponding nonmaterial NCP are not equitably distributed across urban populations. Wealthier neighbourhoods have greater canopy cover in urban areas when compared to low-income communities. High minority concentrations (ethnic race, disabled people) have lower levels of access to green space coverage. *Landry et al. 2009, Jennings et al. 2012 and 2016, Wolch et al. 2014*	Many local medicinal plants are sold to regional, national and global markets for improving human health elsewhere. *Mathe 2015*
Contribution of biodiversity and green spaces to mental health	Around 55 percent of the world's population is thought to be living in an urban area or city, with that figure set to rise to 68 percent over the coming decades. Having access to green spaces can reduce health inequalities, improve well-being, and aid in treatment of mental illness. Some analysis suggests that	(A) In urban areas, which host more than 50% of global population, there is a threshold response at which the population prevalence of mental-health issues is significantly lower beyond minimum limits of neighbourhood vegetation cover (depression more than 20% cover, anxiety more than 30% cover, stress more than 20% cover). Therefore, in order to promote mental health, an increase of neighbourhood vegetation cover in urban areas to 20% cover by 2030 and 30% cover by 2050 is needed.	Green spaces and corresponding nonmaterial NCP are not equitably distributed across urban populations. Public parks associated outdoor recreation opportunities represent a critical physical activity resource in low-income and minority communities. Studies of	Geographic distances can affect the likelihood of visiting parks and natural areas for many people *Hanink and White 1999, Zhang et al. 1999*

	physical activity in a natural environment can help remedy mild depression and reduce physiological stress indicators. *UN World Urbanization Prospects (2018)* https://esa.un.org/unpd/wup/Download/ https://www.who.int/sustainable-development/cities/health-risks/urban-green-space/en/ http://www.euro.who.int/en/health-topics/environment-and-health/urban-health/publications/2016/urban-green-spaces-and- health-a-review-of-evidence-2016 http://www.euro.who.int/en/health-topics/environment-and-health/urban-health/publications/2017/urban-green-space-interventions-and-health-a-review-of-impacts-and-effectiveness.-full-report-2017	*IPBES 2018* (B) Respondents living more than 1 km away from a green space (forest; park, green space; beach, sea, lake; and other green space) have 1.42 higher odds of experiencing stress than do respondents living less than 300 m from a green space. Respondents not reporting stress are more likely to visit a green space than are respondents reporting stress. *Stigsdotter et al. 2010* In addition, studies in various groups such as students, inner city girls and workers reported associations between green space with a variety of psychological, emotional and mental health benefits. Therefore, it is needed to enhance the access to nature and green spaces to increase mental and emotional health, including women, disabled people and ethnic minorities. *Pretty et al. 2003, Martinez-Alier and Popham 2008, Abercrombie et al. 2008, Hillsdon et al. 2008, Lee and Maheswaran 2010*	green areas use note that women, ethnic minorities, poor people and people with disabilities were less likely to use green spaces. *Cohen et al. 2007, Jennings et al. 2012 & 2016, Hillsdon et al. 2008*	
Contribution of biodiversity and green spaces to physical health through the NCP - physical and recreational experiences	Around 55 percent of the world's population is thought to be living in an urban area or city, with that figure set to rise to 68 percent over the coming decades. Physical inactivity, linked to poor walkability and lack of access to recreational areas, accounts for 3.3% of global deaths.	People living within a mile of a park were four times more likely to use it once a week or more, and had 38% more exercise sessions per week than those living further away. *Cohen et al. 2007* Modification of the built environment to provide green space offers opportunities for beneficial "green exercise" such as walking.	Green spaces and corresponding nonmaterial NCP are not equitably distributed across urban populations. Wealthier neighbourhoods have greater canopy cover in urban areas when compared to low-income communities. High minority concentrations	Geographic distances can affect the likelihood of visiting parks and natural areas for many people *Hanink and White 1999, Zhang et al. 1999*

	UN World Urbanization Prospects (2018) https://esa.un.org/unpd/wup/Download/ https://www.who.int/sustainable-development/cities/health-risks/urban-green-space/en/ https://www.who.int/sustainable-development/cities/health-risks/urban-green-space/en/ http://www.euro.who.int/en/health-topics/environment-and-health/urban-health/publications/2016/urban-green-spaces-and- health-a-review-of-evidence-2016 http://www.euro.who.int/en/health-topics/environment-and-health/urban-health/publications/2017/urban-green-space-interventions-and-health-a-review-of-impacts-and-effectiveness.-full-report-2017	*Pretty et al. 2003, Lee and Mahewswaran 2010* Therefore, it is needed to build green areas in urban systems and enhance the access to nature and green spaces to provide opportunities for physical activities, including women, poor people, disabled people and ethnic minorities. *Abercrombie et al. 2008, Hillsdon et al. 2008, Martinez-Alier and Popham 2008, Maas et al. 2009*	(ethnic race, disabled people) have lower levels of access to green space coverage. *Landry et al. 2009, Jennings et al. 2012 and 2016, Wolch et al. 2014*	
Regulation of air quality	Ambient air pollution accounts for an estimated 4.2 million deaths per year due to stroke, heart disease, lung cancer and chronic respiratory diseases. Around 91% of the world's population live in places where air quality levels exceed WHO limits. https://www.who.int/health-topics/air-pollution	Air quality problems could be diminished by increasing native habitats within working landscapes. The need of 20% of native habitat area within working landscapes emerge as a minimum requisite. *Garibaldi et al. under review*	Wealthier neighbourhoods have greater canopy cover in urban areas when compared to low-income communities. *Jennings et al. 2012 and 2016*	Many air pollutants are from distant places, and affect those downwind. *Tan et al. 2018*

Regulation of detrimental organisms - scavenging	In the near-complete absence of vultures, human health costs from rabies increased dramatically due to increasing populations of wild dogs. *Markandya et al. 2008, Ogada et al. 2012*	Scavengers can have an important role in mitigating risk of disease spread by reducing the persistence of carcasses of diseased animals. In the near-complete absence of vultures, human health costs from rabies increased dramatically due to increasing populations of wild dogs. Therefore, it is needed to halt the loss of vulture populations since they are the most successful scavengers. Presently, 14 of 23 (61%) vulture species worldwide are threatened with extinction, and the most rapid declines have occurred in the vulture-rich regions of Asia and Africa. *Markandya et al. 2008, Ogada et al. 2012*	The vast majority of people bitten by wild dogs (whose populations increased due to the decrease of vulture populations) and infected by rabies belong to “poor” or “low” income economic groups (87.6%). The most rapid declines have occurred in the vulture-rich regions of Asia and Africa. The ancient custom of sky burial by the Parsi community, similarly practiced by Tibetan Buddhists, has come to an abrupt end in the last decade due to the collapse of vulture populations. *Verdoorn et al. 2004, Ogada et al. 2012*	The large decline of Gyps vulture in Asia was due to poisons from other places. *Loveridge et al. 2018*

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