FAQ: Ecosystem Integrity in the Post-2020 Global Biodiversity Framework

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Section I. Defining ecosystem integrity

Q1: What does ecosystem 'integrity' refer to?

A: Ecosystem 'integrity' refers to the completeness and functionality of an ecosystem, in relation to its natural state.

Many closely-related definitions of ecosystem integrity (or ecological integrity) exist in the literature. Most centre on how close an ecosystem is to its natural state (or, more precisely, its natural range of variation) and most highlight three aspects of the combined biotic and abiotic system that should be considered in judging this – composition, structure and function (Noss 1990). An equivalent way to think of integrity is the degree to which an ecosystem is free from human modification of those three aspects.

One widely cited definition, formulated on the back of previous research, for ecosystem integrity is, '*the ability of an ecological system to support and maintain a community of organisms that has species composition, diversity, and functional organization comparable to those of natural habitats within a region*' (Parrish Braun and Unnasch 2003). This definition can be made operational as follows: '*An ecological system or species has integrity or is viable when its dominant ecological characteristics (e.g., elements of composition, structure, function, and ecological processes) occur within their natural ranges of variation and can withstand and recover from most perturbations imposed by natural environmental dynamics or human disruptions*.'

This framing of ecological integrity is closely related to, or includes, several other widely used terms used to describe traits or aspects of ecosystems. We have explained the relationship of integrity to these terms in Questions 3-7 below.

Q2: Why is it important to define ecosystem integrity?

A: The benefits provided by an ecosystem depend not only on its extent but also on its ecological integrity.

With ecosystem loss and degradation being the major drivers of the loss of biodiversity and ecosystem services across the world, it is of increasing interest to document and properly safeguard what remains. The extent of an ecosystem is not the only determinant of the benefits it provides to both the natural world and to humans, because the condition of an ecosystem - that is, its integrity - is also critically important. There have been several terms related to ecosystem condition in international or intergovernmental policy frameworks, but integrity is widely used and is the most comprehensive term. This document seeks to clarify the use of the term in light of its inclusion in negotiations of the post-2020 global framework for biodiversity (see Section IV).

Declines in integrity generally mean reduced suitability of habitat for native biota, disrupted ecological processes and functions, and diminished ecosystem resilience and capacity to sustain species and to continue to provide many ecosystem services, especially those that represent 'public goods' such as regulatory services (e.g. for climate and water).

Q3: What is the relationship between the terms 'integrity', 'intactness' and 'intact'?

A: 'Integrity' and 'intactness' can be treated as synonymous for many purposes, although intactness may have different connotations for some audiences and should be used with care. 'Intact' has a distinct, narrower meaning, equivalent to 'very high integrity.'

For the purposes of this document we consider ecological integrity and ecological intactness to be synonymous – that is, they both describe the extent to which the condition of an ecosystem is within the natural range (and hence free from human modification), taking into account composition, structure and function. Historically, the term "ecological integrity" has a stronger history of usage than 'intactness' in international policy arenas, and is generally less binary in its conception than intactness, and so we focus on using the term integrity in this policy-oriented document.

The term 'intact' is slightly distinct from both 'intactness' and 'integrity.' It represents an effort to categorize the level of ecological integrity, rather than seeing integrity as being measured on a continuous scale. An 'intact' example of an ecosystem is one whose level of integrity (or intactness) is above a certain threshold. To avoid confusion, we recommend that users of the term 'intact' should be explicit in specifying the threshold they are using when they apply the term.

Different users may choose to set different thresholds for an 'intact' ecosystem in different contexts. In some cases, the threshold may be set, explicitly or implicitly, to equate to the maximum possible level of integrity, with *absolutely no evidence of human modification* at all. In others the threshold may be set at a slightly lower level considered to indicate no *significant* human modification – for example, Intact Forest Landscapes (Potapov et al. 2017) must by definition exceed 500 km^2 in size, but since many such areas are in fact surviving 'fragments' even larger forest blocks this threshold allows some history of human modification. The absolute absence of human modification is very rare anywhere in the world (at least terrestrially); in practice almost all forests have at least some small detectable degree of human modification, even if it is just minor modifications at the edges, or changes in the populations of wide-ranging migratory species. Climate change is another extremely pervasive process that arguably represents human modification of an ecosystem. As such, when the term 'intact' is used for an area, we believe clarity must be provided on how these areas were found to be 'intact' and why other areas were not.

Q4: What is the relationship between the terms 'integrity' and 'quality'?

A: Integrity and quality can be used interchangeably in some contexts, but some aspects of the very broad term 'quality' are not covered by the term 'integrity'.

Ecosystem quality is a general term which can mean quite different things depending on the context and how the term is defined by the person using it. One way to use it is to refer to the degree to which the ecosystem provides a range of values relative to other similar examples of the same ecosystem, which in practice is then similar to the term integrity. However, the term quality is also often used to compare the way in which different ecosystems deliver a given service or value at different levels - for example, one could state that a high integrity evergreen forest has higher habitat quality for a given primate species than an equally high integrity deciduous forest nearby – in which case the difference would be natural and not relevant to the concept of integrity.

Q5: What is the relationship between the terms 'integrity' and 'degradation'?

A: Degradation refers to reductions in the ability of an ecosystem to deliver specified values. In principle a loss of integrity may result in degradation with respect to some values but an enhancement with respect to others.

The terms integrity and degradation are closely related (Watson et al. 2018). Degradation refers to reductions due to human action (or possibly other external pressures) in the ability of an ecosystem to deliver certain specified services or values. Loss of integrity typically reduces the ability of an ecosystem to deliver many services (see Question 1, above) and so it can be said to represent degradation with respect to all of those values. Hence, when the context explicitly relates to environmental services, such as the status of biodiversity, carbon stocks or watershed values, it is accurate to speak of an ecosystem with reduced integrity as degraded.

However, reduced integrity may (up to a point) allow an increase in the productivity of certain provisioning services (e.g., natural resource extraction) and so technically the ecosystem is not degraded with respect to those services. Even in such cases, over-extraction, the degradation of regulatory services, may undermine the long-term sustainability of provisioning services.

Q6: What is the relationship between the terms 'integrity' and 'functionality'?

A: The term 'functionality' may or not be included in the concept of 'integrity', depending on how 'functionality' is defined.

The definition of integrity in Question 1 explicitly includes levels of ecosystem function that are similar to the natural range of variation, so for many purposes the concept of integrity can be assumed to include functionality. However, if a given audience defines functionality in a different way than the services provided by natural systems, for example if 'high functionality' in their view refer to high levels of specific provisioning services, then it is not covered by the concept of integrity as defined here.

Q7: Can an area used by humans have high integrity?

A: Yes it can, in principle, because human presence alone does not reduce integrity. However, human modification of an ecosystem beyond its natural range of variation does reduce its integrity.

Human presence or even use of the ecosystem does not necessarily alter the attributes of composition, structure or function, which make together make up integrity as defined in Question 1, beyond their natural range of variation. However, if human uses become sufficiently large in scale (intensity and/or extent), they are likely to alter those components of integrity beyond natural ranges of variation and so integrity will therefore be reduced.

Q8: Ecosystem integrity is often used in the context of forest or coral reef ecosystems (e.g. Aichi Target 10) - is this term relevant for all ecosystem types/biomes?

A: The concept of ecosystem integrity is applicable to all natural ecosystem types.

The concept of ecosystem integrity is broadly defined and universally applicable across all natural ecosystems in all biomes; it is relevant to all terrestrial, freshwater, and marine ecosystems, as they all

depend on the interactions between species and the biotic and abiotic aspects of their habitat. To this point, ecosystem integrity is addressed explicitly in reference to coral reefs and other climate-vulnerable ecosystems in CBD Aichi Target 10.

However, this concept is not especially useful when considering ecosystems created by people by wholly converting natural ecosystems (e.g. farmland or cities). By the definition in Question 1 such ecosystems undoubtedly have very low ecological integrity. However, alongside this fact, a complementary framing of ecosystem condition is also required that focuses on the valued services and functions that such ecosystems now provide.

Section II. Assessing or measuring ecosystem integrity

Q9: How can ecosystem integrity be assessed or measured?

A: Ecosystem integrity is a broad concept, and there are different ways to measure it based on the available data and intended uses of the measure.

Levels of ecosystem integrity can be measured by assessing the degree to which the component attributes (composition, structure and function) remain within the natural ranges of variation. In the absence of sufficient data, an alternative means is to measure certain proxies (such as human pressure, or population viability of area-sensitive species) which relate to these attributes.

Integrity is not a binary (either/or) characteristic; it inherently exists on a gradient from high to low. However, like any continuous variable it can be reduced to a categorical variable (e.g., high/low integrity) if that is more appropriate for a desired application.

As three component attributes are involved, and each of those in turn relate to a range of specific characteristics of an ecosystem, various measures of integrity are possible, depending on data availability and the intended use of the measure. One could emphasize a measure that focuses on integrity with respect to a particular aspect of the system (e.g., integrity of hydrological functions) or a broader measure that responds to changes in multiple aspects of the system (e.g., condition of an indicator species community). In the latter case multiple attributes might be measured, and the values combined to provide an index.

This diversity of options is a result of the complex, multi-dimensional nature of integrity, which is comparable to the complex, multi-dimensional nature of biodiversity itself. As with biodiversity, no single measure can capture all aspects of the concept for all purposes, and a family of complementary measures is needed to fully characterize the integrity of ecosystems across different scales and biomes.

Q10: What scale should integrity be measured at?

A: Integrity can be measured at any scale from global to local, using the best available information at each scale.

Ecosystem integrity is generally most easily measured with precision at local to regional scales in places where field data availability is high. The metrics used can then be tailored to key local ecological factors and local data may be very up to date, with high levels of detail. For example, much early work on the concept was conducted in freshwater ecosystems in the USA using direct field observations.

Larger-scale global and regional-scale assessments of integrity that draw on remotely-sensed data are increasingly being developed, responding to the planetary scale of the biodiversity crisis, the absence of local data in many areas, and increasing availability of remote-sensed data that can serve as proxies for measuring on-the-ground values. Such analyses have great value for understanding and comparing the relative condition of many areas together, but may have lower precision at fine geographical scales than targeted local studies. Both scales play an important role in enhancing our understanding of the state of the biosphere.

Q11: Can ecosystem integrity be measured for all ecosystem types?

A: Yes, although the tools or indicators can vary.

In principle, integrity can be measured for any ecosystem, if key attributes that respond to human activities can be identified and quantified (either on their own or through measurement of the human activities as proxies). Some generic measures have been developed that apply across many ecosystems, whilst other measures exist or can be developed that are specific to a given ecosystem. Baseline data already exist against which to measure ecosystem integrity for many ecosystem types.

In the terrestrial realm there are numerous papers in the peer-reviewed literature that assess ecosystem integrity at global scales using a range of approaches that incorporate global datasets for human activities – thereby using the proxy method of measuring integrity (e.g. Watson et al. 2016; Venter et al. 2016, Beyer et al. 2019). There are also measures developed for specific ecosystems (e.g. Potapov et al. 2017; Hansen et al. 2019 for forests). Similar studies have been undertaken in the marine realm, using datasets of cumulative human pressures on marine ecosystems (Halpern et al. 2015; Jones et al. 2018). Many other datasets and tools are being developed, and will increase our ability to measure integrity at different scales over the coming years.

Q12: Are there special considerations for measuring integrity in marine ecosystems?

A: Yes, and this is an active area of research.

Due to the unique ecologies of marine environments, particularly pelagic and benthic habitats, and challenges in measuring some of the anthropogenic pressures on marine ecosystems, there are special considerations in how to evaluate marine ecosystem integrity.

Some datasets on cumulative human pressure on marine ecosystems already exist (Halpern et al. 2015), and they can help us measure ecosystem integrity by proxy. For example, Jones et al. (2018) used related datasets to identify relatively large patches high integrity marine areas ("marine wilderness") at a global scale. However, some differences in the distribution of human activities in the marine environment means that complementary work to study those component aspects of ecological integrity (composition, structure, function) continue to be critical. For example, some hugely biodiverse coastal coral reef ecosystems are located in close proximity to modified or high traffic coastal ecosystems, and can also be managed for food and economic security in addition to preservation of biodiversity. Locally-driven, bottom-up approaches to collecting and aggregating data on ecosystem condition (e.g. through hard coral cover and reef fish biomass) continues to be a vital means of assessing the extent and integrity of these ecosystems (GCMRN, MERMAID).

Q13: What is the Forest Health Index? What can it be used for?

A: WCS and other partners in a scientific consortium are developing a global metric for forest ecosystem integrity.

A scientific consortium (including scientists from WCS, University of Queensland, University of Oxford, the World Resources Institute, and WWF) has been working to develop a global tool for measuring the health of all forest ecosystems (tropical, boreal, etc.). This Forest Health Index (FHI) will indicate the condition of a forest ecosystem, relative to the natural, undisturbed state in a given locality, based on a holistic assessment of the degree to it has or has not been modified by human action. The underlying principles behind the metric can be re-applied to other ecosystem types, making this a powerful demonstration of

how innovative science can drive effective monitoring of habitat degradation, fragmentation and loss in a post-2020 framework. [Note: WCS and partners are submitting the FHI for peer review in early 2020.]

Q14: Some of the maps based on the concept of wilderness or intact ecosystems do not include my country or region. Is this concept relevant to all?

A: Mapping exercises based on thresholds for areas with very high integrity may exclude some countries or regions, but the broader concept of integrity is relevant for everyone and everywhere.

There have been several recent global studies relating to the concept of ecosystem integrity, some of which focus on identifying the areas with the highest levels of ecosystem integrity, or the most intact ecosystems (Watson et al. 2016; Venter et al. 2016; Jones et al. 2018). Using a standard global threshold, the areas which qualify as 'high integrity' or 'intact' tend to be concentrated in certain large, remote regions, with little or no representation in other, more densely populated regions. However, these simple threshold-based approaches sacrifice a great deal of ecological detail because integrity, and hence the relative level of values offered by ecosystems, vary across a gradient. Hence even in countries or regions where no land qualifies as high integrity at a global scale, it is still important to distinguish those areas of a given ecosystem that have *relatively* high integrity, and hence higher levels of many values, within that geographical area. In this way, the concept can be used by all countries and at multiple scales.

Section III. Ecological integrity in international policy

Q15: Does ecosystem integrity appear in national and international policy?

A: Ecosystem integrity is reflected in both international agreements (hard and soft law) and national policies.

The importance of ecosystem integrity in environmental policy stems from Principle 7 of the 1992 Rio Declaration on the Environment and Development, which states that "*States shall cooperate in a spirit of global partnership to conserve, protect and restore the health and integrity of the Earth's ecosystem*." The concept of ecosystem integrity has been used in intergovernmental agreements and policy fora, including as part of the Operational Guidelines for the UNESCO-World Heritage Convention in 1978, and the 2015 Paris Agreement under the United Nations Framework on Climate Change (whose preamble notes "*the importance of ensuring the integrity of all ecosystems, including oceans*").

Parties to the Convention on Biological Diversity, which followed directly from the Rio Declaration and its Principles, have agreed on the value of ecosystem integrity to ecosystem-based solutions to climate change adaptation and disaster risk reduction, including the adoption of relevant guidance on climate change adaptation and disaster risk reduction at CBD CoP14. Furthermore, ecosystem integrity is mentioned in the current CBD Strategic Plan's Aichi Target 10 on climate-vulnerable ecosystems (see below).

More recently, the *Guidelines for Identification of Key Biodiversity Areas* (the "KBA Standard") were adopted by the IUCN Congress in 2016 and are increasingly in use to identify important sites for the persistence of biodiversity in countries including Mozambique, Australia, Uganda, Canada, and several others. The KBA Standard has a special criterion dedicated to ecological integrity.

At the national level, some countries have used ecosystem integrity as a guiding principle in national legislation or regulation, such as Canada's legislation on national parks.

Q16: Is ecosystem integrity explicitly defined in these national or international policies?

A: Yes - but while the underlying concept is shared by all of these policy frameworks, specific definitions and/or thresholds vary.

Several definitions exist across these different policy frameworks, which have slight differences in phrasing but are generally aligned. For example, the current Operational Guidelines of the UNESCO World Heritage Convention define integrity as "*a measure of the wholeness and intactness of the natural and/or cultural heritage and its attributes*." Canada's legislation for national parks defines ecosystem integrity as, "*…a condition that is determined to be characteristic of its natural region and likely to persist, including abiotic components and the composition and abundance of native species and biological communities, rates of change and supporting processes*." The KBA Standard has a special criterion for sites that meet a standard for ecological integrity, defined as those "*...Essentially undisturbed by significant industrial human influence," and that "maintain their full complements of species in their natural abundances or biomass, support the ability of species to engage in natural movements, and allow for the unimpeded functioning of ecological processes*." Specific indicators or measurements or thresholds used to assess ecological integrity vary across ecosystem types, and have evolved over time.

Q17: How is ecosystem integrity reflected in current Strategic Plan for Biodiversity and Aichi Targets, as adopted by Parties to CBD in 2010?

A: Ecosystem integrity appears both explicitly and implicitly within the Aichi Targets (Targets 5 and 10), but challenges with definition and organization have hindered implementation efforts.

Ecosystem integrity is mentioned explicitly in Aichi Target 10: "*By 2015 the multiple anthropogenic pressures on coral reefs, and other vulnerable ecosystems impacted by climate change or ocean acidification are minimized, so as to maintain their integrity and functioning*." Aichi Target 5 addresses ecosystem degradation (which includes a wide range of pressures such as fragmentation, logging, overgrazing, over-hunting, overfishing and changes to fire and hydrological regimes), which can be seen as the inverse of, or primary threat to, ecosystem integrity. Unfortunately, both Aichi Targets 5 and 10 (and some others) suffer from different types of ambiguity that has led to confusion and relatively poor implementation (Butchart et al. 2016, SBSTTA 2018).

Meanwhile, scientific research has shown that the planet is losing natural habitat and high integrity ecosystems at an alarming rate (Watson et al. 2016) and the CBD SBSTTA has concluded that Aichi Targets 5 and 10 have not been achieved by Parties (SBSTTA 2018). At the same time, our understanding of the exceptional value of intact ecosystems for both biodiversity conservation and climate change mitigation/adaptation is increasing (Watson et al. 2018). We can address this imbalance not only through implementation or funding to deliver on our existing goals and targets, but also by increasing their clarity and measurability.

Q18: Parties to CBD have approved the "Biodiversity Intactness Index" as an indicator for the Aichi Targets. Does this evaluate ecosystem integrity or intactness?

A: The current formulation of a Biodiversity Intactness Index is species-focused, not ecosystem-focused.

The Biodiversity Intactness Index (BII) has been approved by CBD's Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) as an indicator for Aichi Target 12 on species. It models the estimated response of one key aspect of ecosystem structure (abundance of species). It therefore has high applicability to questions relating to the structure aspect, insofar as it is found to have good statistical performance, but because it focuses on one element it is less relevant to broader questions that relate to ecosystem integrity as a whole. It also has uneven accuracy across the globe. The underlying model does include a human pressure index that could potentially form a proxy for ecosystem integrity as a whole, and hence might function as a broad indicator of ecosystem integrity in its own right, but the index used appears less sophisticated than some other available indices of human pressure and would require careful comparative assessment.

Section IV. Ecosystem integrity in the post-2020 global biodiversity framework

Q19: Why is ecosystem integrity critical in the post-2020 global biodiversity framework?

A: Ecosystem integrity is essential for delivering on the ecosystems component of biodiversity, and also underpins critical ecosystem services that contribute to other international goals, including the SDGs.

High integrity ecosystems are critical for biodiversity conservation, as species need sufficient habitat and intact species assemblages to survive an increasing number of local and global threats (including climate change). Existing and forthcoming research highlights the critical contribution of wilderness or intact ecosystems to biodiversity conservation (e.g. DiMarco et al. 2019). This makes the concept critically important to achieving the biodiversity conservation objectives of the CBD. However, high levels of ecosystem integrity also contribute to other environmental values and provide ecosystem services, including carbon storage and sequestration, fisheries replenishment, disaster risk reduction, and economic and food security (Watson et al. 2018; Martin and Watson 2016). In this way, maintaining high levels of ecosystem integrity will also deliver on other aspects of the CBD, including sustainable use of biodiversity, and will also directly contribute to other international commitments on climate change, fisheries, etc., as well as the Sustainable Development Goals. This provides a critical link between the agenda of the CBD and other international agreements, which has been specifically requested by Parties.

Q20: How would prioritizing ecosystem integrity affect existing and planned obligations under the CBD and other international treaties?

A: A goal on ecosystem integrity in the post-2020 biodiversity framework will provide an overarching objective that can inspire appropriate interventions at different scales.

Aichi Targets such as 5 and 10 already set critical goals that explicitly or implicitly addressed ecosystem integrity, but they also suffered from ambiguity and an unclear logical structure that led to confusion and relatively poor implementation (Butchart et al. 2016, SBSTTA 2018). This was not flagged as a major area of concern, as, until relatively recently, high-integrity ecosystems were not regarded as particularly limited at a global scale. However, we now have a greater understanding of recent losses in ecosystem integrity, the disproportionate value of intact systems, and the challenges in restoring ecosystems once they have been degraded or lost. Without a clear, overarching and actionable target for ecosystem integrity, the implementation of existing targets will all too often default to managing degradation and fragmentation in a piecemeal manner. It is therefore very urgent to improve the clarity and elevate the importance of goals and targets addressing ecosystem integrity post-2020. We must also work to improve the the indicators used to report on progress towards these integrity-relevant goals and targets, including developing standardized global metrics that allow Parties to facilitate reporting and increase accountability.

Q21: Does ecosystem integrity appear in the 'zero draft' of the post-2020 global biodiversity framework (January 2020)?

A: Yes, ecosystem integrity is positioned alongside ecosystem extent within ecosystem-related goals and targets in the zero draft.

The inclusion of an ecosystem goal on area and integrity of ecosystems as proposed in paragraph 10(a) of the zero draft is a critical component of a post-2020 global biodiversity framework. We strongly support the proposed inclusion of both area (extent) and integrity (completeness of, quality and function, including connectivity) of ecosystems, and urge Parties to further refine (and add to) the indicators for measuring these critical concepts across different ecosystem types. The ecosystem goal (along with the other

2030/2050 goals) provides a strong overarching framework for implementation of action-oriented targets in Section D of the zero draft, including the action target for spatial planning in paragraph 12(a)(1). Many action targets will contribute to retention and restoration of ecological integrity, and we believe the scope of existing action targets is appropriate to achieve the goal at national, regional and global levels.

Further feedback on goals and targets that address ecosystem integrity, including more specific comments on the phrasing of the text and on indicators, can be found it the WCS position statement on the zero draft.

Q22: How should Parties identify indicators to measure progress towards goals or targets addressing ecosystem integrity?

A: Some indicators are already available, but additional indicators will need to be identified that measure aspects of ecosystem integrity.

The 2030/2050 goals on ecosystems as presented in paragraph 10(a) of the 'zero draft' are phrased to be applicable across all ecosystems, but the indicators used to measure progress towards this goal will necessarily be more specific. At present, scientists have shown that ecosystem integrity can be measured in a standardized way across terrestrial biomes using anthropogenic disturbance (Beyer et al. 2019), and tools such as the Forest Health Index are being developed that will allow for a more thorough, standardized evaluation of ecosystem integrity for forest ecosystems. For other ecosystem types, such as marine environments, there will be other means of measuring anthropogenic pressures at a global scale (Halpern et al. 2015). For more specific marine ecosystem types, such as coral reefs, other tools for evaluating essential ocean variables will need to be used (for example, coral reef indicators could include live coral cover, reef fish biomass and structural complexity) and combined with global datasets on ecosystem extent or pressure that are increasingly available (for coral reefs, this could include datasets on coastal development, thermal conditions, etc.).

Across all ecosystems, regional and national data are increasingly available that can be used to measure ecological integrity with higher precision and accuracy than can usually be achieved with global datasets. This should be encouraged, as long as these more localized studies meet similarly high levels of scientific rigor.

Q23: Are there ways to address the differences in ecosystem dynamics and availability of data for different ecosystems through the structure of the framework?

A: We see two options for dealing with discrepancies among ecosystem types: biome-specific sub-targets or improved indicators.

One option would be to develop biome-specific sub-targets underneath the 2030 and 2050 goals for ecosystems that would allow CBD Parties to set quantitative, SMART thresholds or targets by ecosystem type or biome for 2030. Alternatively, a second option is to develop an overarching goal that is SMART and applicable to all ecosystems, and develop indicators that address each biome. These indicators would then be used to reflect on efforts to maintain or increase the integrity of various ecosystem types at the national level or otherwise.