Frequently Asked Questions:
Ecosystem Integrity and International Policy
August 2021 | Contact: slieberman@wcs.org

Contents:

Executive Summary

Note: Drawn directly from this document. To be translated into Spanish, French, Arabic, Chinese.

Integrity is the degree to which an ecosystem's composition, structure, and function are similar to its natural or reference state.

Many closely related definitions of ecosystem integrity, sometimes referred to as ecological integrity, exist in the peer-reviewed literature. Most center 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 (including, for example, presence and diversity of species), structure (e.g. organizational attributes like connectivity, fragmentation), and function (e.g. productivity, disturbance regimes, and functional connectivity) (Noss 1990; Nicholson et al. in press). One widely cited definition for ecosystem integrity, drawing on previous research, 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).

Of course, ecosystems have changed over millennia in response to glaciation and other natural phenomena. Furthermore, human beings have interacted with certain ecosystems for thousands of years, in some cases permanently changing aspects of those ecosystems' composition, structure or function (Ellis et al. 2021). This means that, in some cases, it is difficult to identify an ecosystem's "natural" state across all of its attributes, and a "reference" state is used (Hansen et al. 2021). Therefore, another practical way to think of ecosystem integrity, relevant to a wide variety of ecosystem types, can be the degree to which an ecosystem is free from anthropogenic modification of any of those aspects (composition, structure and function) to the point where the expected functionality of the ecosystem is diminished relative to a chosen historical baseline (Bridgewater et al. 2014).

Some research focuses on the *loss* of natural ecosystems using binary measures of extent (e.g. of forest cover). However, the extent of an ecosystem is not the only determinant of the benefits it provides to both the conservation and the sustainable use of biodiversity. The integrity of an ecosystem is also critically important. Many ecosystems, in particular marine ecosystems, are evaluated primarily or even only by their integrity or condition (e.g., live hard coral cover for tropical coral reefs), rather than their extent -- as outright conversion of marine ecosystems is much rarer than for terrestrial ecosystems.

An ecosystem's integrity can be measured by assessing the degree to which its component attributes (composition, structure, and function) remain within their natural or historic ranges of variation and retain functionality accordingly. It can also be measured through proxies like human pressure indicators that are proven to be associated with impacts on integrity and the degradation of ecosystem functionality. As three component attributes are involved, different measures of integrity are possible depending on the exact parameters selected, data availability and the intended use of the measure. Ultimately, the concept of ecosystem integrity is broadly defined and universally applicable across all natural ecosystems in all biomes; what varies most significantly are the tools available and practices used to measure ecosystem integrity across these different ecosystem types.

Many ecosystem types are evaluated with respect to evidence-based thresholds, below or beyond which they are expected to lose key biodiversity values and, as a result, the ability to sustain their functionality. However, the process of ecosystem degradation, and the loss of ecosystem functionality, begins far before reaching these thresholds. It is therefore important to note that ecosystem integrity is not binary; it is measured on a continuum or spectrum. However, there are ways to categorize the integrity of ecosystems based on identified thresholds.

Ecosystem integrity has been referenced in several international policy instruments. It is perhaps most well-known from Principle 7 of the 1992 Rio Declaration on the Environment and Development. The concept of ecosystem integrity has subsequently been used in intergovernmental agreements and policy fora, including, for example, the preambular text to the 1980 Convention on the Conservation of Antarctic Marine Living Resources and the 2015 Paris Agreement under the United Nations Framework on Climate Change. The CBD's Aichi Biodiversity Targets, including 5 and 10, already explicitly or implicitly addressed ecosystem integrity, but suffered from ambiguity that led to confusion and relatively poor implementation (Butchart et al. 2016).

Ecosystem integrity is appropriately emphasized, in Goal A in the July 2021 Draft 1 of the post-2020 GBF. Goal A recognizes that the concept of integrity is relevant to all ecosystems, including managed and modified ecosystems, and that Parties can measure increases or enhancements in ecosystem integrity. However, current "headline" indicators for Goal A do not sufficiently address ecosystem integrity. There current reviews of indicators for ecosystem integrity found in Nicholson et al. (in press) and Hansen et al. (2021) that can be used to further develop this part of the monitoring framework. Without clarity on how "component" or "complementary" indicators will be addressed by Parties, a failure to include a headline indicator, or indicators, clearly addressing integrity will ultimately hinder our collective ability to achieve Goal A and the 2050 Vision of the CBD.

Section I. Defining ecosystem integrity

Q1: What is the definition of ecosystem integrity?

A: Integrity is the degree to which an ecosystem's composition, structure, and function are similar to its natural or reference state.

Many closely related definitions of ecosystem integrity, sometimes referred to as ecological integrity, exist in the peer-reviewed literature. Most center 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** (including, for example, presence and diversity of species and characteristics of their populations), **structure** (e.g. physical, organizational attributes like connectivity, fragmentation, spatial arrangement), and **function** (e.g. productivity, disturbance regimes, hydrological processes, nutrient cycling, and functional connectivity, including species movement and dispersal) (Noss 1990; Nicholson et al. in press).

One widely cited definition for ecosystem integrity, drawing on previous research, 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). An expanded definition is as follows: '*An ecological system has integrity or is viable when its dominant ecological characteristics (e.g., elements of composition, structure and function, including 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*.'

Of course, ecosystems have changed over millennia in response to glaciation and other natural phenomena. Furthermore, human beings have interacted with certain ecosystems for thousands of years, in some cases permanently changing aspects of those ecosystems' composition, structure or function. This means that, in some cases, it is difficult to identify an ecosystem's "natural" state across all of its attributes, and a historical "reference state" is chosen (Hansen et al. 2021). Therefore, another practical way to think of ecosystem integrity, relevant to a wide variety of ecosystem types, can be the degree to which an ecosystem is free from anthropogenic modification of any of those aspects (composition, structure and function) to the point where the expected functionality of the ecosystem is diminished relative to a chosen historical baseline (Bridgewater et al. 2014).

Finally, ecosystems are sometimes evaluated with respect to evidence-based thresholds, below or beyond which they are expected to lose key biodiversity values and, as a result, the ability to sustain their functionality. However, the process of ecosystem degradation, and the loss of ecosystem functionality, begins far before reaching these thresholds. It is therefore important to note that ecosystem integrity is not binary; it is measured on a continuum or spectrum. However, there are ways to categories the integrity of ecosystems based on identified thresholds (see Question 3).

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 scientific research repeatedly confirming that ecosystem degradation and loss are driving biodiversity loss and the decline of ecosystem services, it is of increasing interest to document and properly safeguard the integrity, and therefore the functionality, of natural ecosystems that remain.

Some research focuses on the *loss* of natural ecosystems using binary measures of extent (e.g. of forest cover). However, the extent of an ecosystem is not the only determinant of the benefits it provides to both the conservation and the sustainable use of biodiversity. The integrity of an ecosystem is also critically important. Many ecosystems, in particular marine ecosystems, are evaluated primarily or even only by their integrity or condition (e.g., live hard coral cover for tropical coral reefs), rather than their extent -- as outright conversion of marine ecosystems is much rarer than for terrestrial ecosystems.

Declines in ecosystem integrity generally mean reduced suitability or availability 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) and the prevention of zoonotic pathogen spillover. Such ecosystem change brings about different outcomes for various species, with "winners" and "losers" that result in changes in both composition and relative abundance of constituent ecosystem elements.

Ecosystem integrity has been one of the most widely used and comprehensive terms within intergovernmental policy to refer to an ecosystem's completeness and functionality (see Question 13), which has direct implications for services provided to humans for sustainable development. It is therefore critical to clearly define the term ecosystem integrity and to integrate it as a core concept in global environmental governance.

Q3: What is the relationship between integrity and terms like 'condition,' 'quality,' and 'functionality?'

A: The definitions can be similar and they are often used interchangeably, but integrity is the most comprehensive term that examines ecosystem composition, structure *and* function, including in relation to its natural state.

Terms like "condition' and 'quality' are widely used in general writing, often without formal definitions being provided, to describe the current status of an ecosystem compared to some reference condition, implicitly an undamaged condition. When used in this everyday sense it largely overlaps with the term 'ecological integrity' as described in this document.

In some cases, definitions are provided and the relationship is made more explicit; for example, the UN System of Environmental Economic Accounting (SEEA) Ecosystem Accounting (EA) statistical framework, recently adopted by the UN Statistical Commission, states that, "condition is assessed with respect to an ecosystem's composition, structure and function which, in turn, underpin the ecological integrity of the ecosystem, and support its capacity to supply ecosystem services on an ongoing basis." (UN Statistics Division 2021).

Furthermore, the UN SEEA EA provides an explanation of ecosystem integrity, drawing on similar peer-reviewed sources as the definition cited above:

> *In ecology, the description of ecosystem condition is strongly rooted in the concept of ecosystem integrity, which implies an unimpaired condition of being complete or undivided (Karr, 1993). Ecosystem integrity is defined as the ecosystem's capacity to maintain its characteristic composition, structure, functioning and self-organisation over time within a natural range of variability (Pimentel & Edwards, 2000). Ecosystems with high integrity or condition are typically more resilient – able to recover from disturbances or to adapt to environmental changes (Holling, 1973). [UN SEEA EA, page 82]*

Sometimes, terms like 'condition' or 'quality' are used to refer to a specific ecosystem attribute or service, which would effectively be a more limited definition than ecosystem integrity more broadly. This is also true of 'functionality,' which can be used, in some cases, to refer to one aspect of an ecosystem's functionality -- e.g. a high level of one provisioning service -- rather than the full suite of biodiversity values and ecosystem services. Ecosystem integrity, on the other hand, refers to the completeness and functionality of an ecosystem overall, or across a wide variety of biotic and abiotic dimensions.

Q4: What about the relationship between the terms 'integrity' and 'intactness,' and terms like 'intact ecosystems' and 'wilderness areas'?

A: 'Integrity' and 'intactness' can be treated as synonymous for many purposes, although terms like 'intact ecosystems' has a narrower meaning: 'very high ecological integrity.'

For the purposes of this document, we consider ecosystem integrity and intactness to be synonymous – that is, they both describe the extent to which the composition, structure and function of an ecosystem is within the natural range of variation and/or free from anthropogenic modification that reduces the resilience of its biodiversity and therefore its functionality. 'Intactness' is therefore used similarly to the other synonyms (condition, quality) described in Question 3. Historically, the term "integrity" has a stronger history of usage than 'intactness' in international policy arenas, and is generally less binary in its conception than intactness (see below), and so we focus on using the term integrity in this policy-oriented document.

The term 'intact,' however, is distinct from both 'intactness' and 'integrity.' 'Intact' is categorical or binary definition, whereas 'intactness' and 'integrity' are broader concepts on a continuum. An 'intact' example of an ecosystem is one whereby the level of integrity (or intactness) is above a certain threshold, as defined by the user. To avoid confusion, we recommend that any users of the term 'intact' should be explicit in specifying the threshold they are using when they apply the term. Ambiguity in these definitions have created challenges; for example, while many studies of "wilderness" areas explicitly define them so as not to exclude Indigenous human presence and interaction with the environment, including sustainable use practices that has been practiced for millennia, the connotations and historical use of this term have created some confusion on how it should be applied through global policy and targets.

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 an absolute minimum of documented human modification or degradation impacting its full suite of functions over a large geographic scale (this is often the intent when defining "wilderness" areas). In others, the threshold may be set at a slightly lower level considered to indicate less *significant* human modification – for example, Intact Forest Landscapes (Potapov et al. 2017) must by definition exceed 500 km² in size, but since many such areas are in fact surviving 'fragments' even larger forest blocks this threshold allows some history of human modification. Ultimately, the determination of an 'intact' ecosystem is subjective and requires a definition.

Q5: Can an area used by, or modified by, humans have high integrity? Can they be intact?

A: Unsustainable levels of use or exploitation can be expected to reduce ecosystem integrity; however, sustainable use, ensured through effective governance and management, has the potential to maintain or increase integrity.

As stated in Question 1, and addressed in Question 5, the absolute absence of human modification is very rare anywhere in the world; in practice, most ecosystems have at least some small detectable degree of human modification, either directly through minor modifications at the edges or changes in the populations of wide-ranging migratory species, or indirectly through the globalized impacts of climate change. Furthermore, it is widely recognized that humans have been interacting with, and in many cases modifying or co-evolving with, natural ecosystems for thousands of years, and that not all human presence or activities are created equal with respect to their impact on biodiversity (Ellis et al. 2021). It is important to stress, when defining ecosystem integrity, or identifying highly intact ecosystems, that human presence and activities do not necessarily or automatically alter an ecosystem's composition, structure, or function beyond, or far beyond, its natural range of variation. The scale (intensity and/or extent) and nature of human interactions with the environment determine their impact on its integrity. Truly sustainable use can and often does co-exist with high integrity or highly intact ecosystems, as Indigenous Peoples have proven for millennia. It is certain types of extractive activities, particularly those taking place on a commercial or industrial scale, that typically alter ecosystems significantly, within a short time span, and reduce their integrity.

This discussion is slightly more complex when considering 'semi-natural' or highly modified ecosystems. Of course, these systems can still be defined in terms of their composition, structure, and function, but when these ecosystems are significantly modified, or even designed by people (e.g. cities, or even some agricultural areas), the integrity relative to its natural range of variation is automatically very low, or alternately the ecosystem itself has been designed to sustain different biodiversity and deliver different ecosystem services. Ultimately, ecosystem integrity can also be applied to anthropogenic ecosystems, albeit through different reference states and indicators for ecosystem components (Nicholson et al. in press) (see Question 11 for more on measurement).

Q6: Is the term ecosystem integrity relevant for all ecosystem types and biomes?

A: Yes, the concept of ecosystem integrity is applicable to all natural ecosystem types, although the answer is more complex for highly modified ecosystems.

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 and the interfaces between these, as they all depend on the interactions between the myriad biotic and abiotic elements that comprise them. What varies most significantly are the tools available and practices deployed to measure ecosystem integrity across these different ecosystem types. This is addressed in more detail in Questions 9 and 10.

Section II. Measuring or assessing ecosystem integrity

Q7: Is it possible to measure or assess ecosystem integrity?

A: Yes. There are different ways to measure it based on the data available and one's objectives.

An ecosystem's integrity can be measured by assessing the degree to which its component attributes (composition, structure, and function) remain within their natural or historic ranges of variation and retain functionality accordingly. It can also be measured through proxies like human pressure indicators that are proven to be associated with impacts on integrity and the degradation of ecosystem functionality. As three component attributes are involved, and each of those in turn relate to a range of specific characteristics of an ecosystem, different measures of integrity are possible depending on the exact parameters selected, data availability and the intended use of the measure.

For example, 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. 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 where the relationship between these activities and attributes is well understood.

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. As integrity is a holistic concept, capturing as much data as possible is essential. To address deficiencies in field data collection and/or availability, pressure-based indicators of anthropogenic modification, where they are available, can help by serving as a reliable proxy (because where humans engage in activities known to significantly modify ecosystems, one can infer changes in an ecosystem's composition, structure, and/or function).

As noted in Questions 1 and 4, integrity is a continuum, and not a binary (yes/no) characteristic of ecosystems; it inherently exists on a gradient from high to low based on the state of various ecosystem attributes. However, like any continuous variable it can be reduced to a categorical variable (e.g. high or low integrity) by creating a threshold if that is appropriate for a desired application. Where science-based thresholds exist, for example generalized thresholds on anthropogenic activities associated with disturbances to ecosystem integrity, or thresholds for specific ecosystem attributes that indicate an ecosystem's loss of functionality and inability to sustain its values and deliver services (e.g. minimum percentage of live coral cover to sustain carbonate production of coral reefs), then these thresholds can be used to provide clear information to decision-makers and natural resource managers.

Q8: 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 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. The integrity of coral reef ecosystems has been measured for decades at various scales using underwater visual census of live coral cover, reef fish biomass, etc.

Larger-scale global and regional-scale assessments of integrity that draw on remotely-sensed data and spatial models 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 and should be continuously tested, validated and improved by comparing to local and regional field assessments of integrity.

Although larger scale studies, derived either from remotely-sensed data, spatial models, or from compilations of locally gathered data provide scientific and political understanding of our cumulative impact on Earth's natural ecosystems and biodiversity, these are most useful for international policy fora and for assessing the contribution of individual countries or regions to the collective human footprint. However, global scale data on species, other than current distributions (and hence richness) are not widely available and/or robust (a challenge for global uptake of biotic integrity indices). IUCN species distribution maps are useful collectively (in large sample sizes where the many errors associated with individual maps get washed out), but local and regional data are often more accurate, and should be encouraged where available to inform practical management of biodiversity.

Q9: Can ecosystem integrity be measured for all ecosystem types?

A: Yes, although the tools or indicators can and will vary across each type of ecosystem.

In principle, the integrity of any ecosystem can be measured, if either a) ecosystem attributes related to composition, structure, or function can be directly measured and compared to a natural (unmodified) or desired reference state (e.g. monitoring of species abundance) and/or b) if human activities known to directly correlated to changes in those ecosystem attributes can be identified, quantified, and monitored. Some generic measures have been developed that apply across many ecosystems, whilst other measures exist or are being developed that are specific to a given ecosystem (see Question 10). Baseline data already exist against which to measure ecosystem integrity for many ecosystem types, and in many cases data collection is already being coordinated by central entities.

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 (WCS has been involved with extensive research on this issue in the past, including 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; and Grantham et al. 2020 for forests). There are complements in the marine realm (Halpern et al. 2019; Jones et al. 2018).

Q10: What indicators are currently available to measure ecosystem integrity?

A: There are a variety of tools available for Party use to measure ecosystem integrity at different scales and for different ecosystems.

With the above general considerations in mind, there are a variety of tools that have been developed to evaluate ecosystem integrity at different scales and for different ecosystem types. Some key examples that WCS has developed or worked with are provided in Figure 1, below. Some recent reviews of relevant indicators can be found in Nicholson et al. (in press) and Hansen et al. (2021).

Realm	Global Indicators (Cross-Cutting)	Ecosystem	Ecosystem-Specific Indicators
Terrestrial	"Human Footprint Index" (HFP) • *Pressure-based:* cumulative, spatially-explicit index is derived from remote sensed and survey data of eight key human pressures (e.g. crop lands, electric infrastructure, roads, etc.) • *Ready for use:* Peer reviewed (Williams et al. 2020), with available baselines and updates made available regularly (at no cost) for reporting "Ecosystem Intactness Index" (EII) • *Pressure-based:* Derived from Human Footprint Index data (see above), but builds on it to assess changes in fragmentation, degradation and connectivity of ecosystems, and as such their relative intactness in relation to a state in which no habitat loss or degradation has occurred. • *Ready for use:* Peer reviewed (Beyer et al. 2019) and approved by the BIP, with available baselines and updates made available regularly (at no cost) for reporting	Forests	"Forest Landscape Integrity Index" (FLII) • *Pressure- and state-based:* cumulative, spatially-explicit index integrates data on a) forest extent, b) localized, directly observable anthropogenic pressures, c) diffuse, anthropogenic pressures inferred based on proximity to localized pressures, and d) anthropogenic alteration of forest connectivity. • *Ready for use:* Peer reviewed (Grantham et al. 2020) and approved by the BIP, with available baselines and updates made available annually (at no cost) for reporting • Read more at forestlandscsapeintegrity.com
Marine (Global	"Cumulative human pressure on marine ecosystems" • *Pressure-based:* cumulative, spatially-explicit index is derived from remote sensed and survey data of eight key human pressures (e.g. commercial fishing, shipping, nutrient pollution) • *Ready for use:* Peer reviewed (Halpern et al. 2019) and approved by the BIP, with available baselines and updates for reporting	Coral Reefs	"Live [hard] coral cover and composition" "Fish abundance and biomass" "Cover of fleshy algae and other key benthic groups" • *State-based:* Relies on compilations of standardized field assessments, which are undertaken as part of consultative global assessments via GCRMN • *Ready for use:* Each indicator is peer reviewed, with available baselines and updates for reporting [details here] • Read more at coralpost2020.org

Figure 1. A selection of available tools/indicators with which to measure ecosystem integrity.

Q11: What "natural" or "historic" baselines should be used to measure ecosystem integrity?

As noted, integrity is measured in relation to a natural state, or, acknowledging the challenges in identifying a natural state in some cases, a historical reference state for composition, structure, and function. Generally speaking, the temporal baseline most relevant to serve as the baseline for measurement of an ecosystem's integrity will vary among locations depending on natural climate variation and human land-use history (Hansen et al. 2021). Pre-industrial baselines generally take into account low-impact human presence and interaction with the environment, but not those industrial activities and transformations that have accelerated and increased our anthropogenic impacts on ecosystems. Practically, baselines for a given ecosystem can be crafted from paleo-ecological reconstructions, or more approximately from process simulation or statistical models, or aerial photographs. Another way to generate a reference state or baseline could be through comparison with higher integrity sites of similar ecological characteristics; in this way, protected and conserved areas that retain their ecological integrity are essential for restoration efforts by providing these reference states.

Q12: Some maps based on the concept of 'wilderness' or 'intact ecosystems' do not include my country or region. Is this concept relevant globally?

A: Such mapping exercises use thresholds for areas with *very high* integrity, but the broader concept of integrity is relevant across different histories of ecosystem transformation and essential at the global scale.

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 based on reduced presence of anthropogenic disturbance and degradation (Watson et al. 2016; Potapov et al. 2017; Venter et al. 2016; Jones et al. 2018). By applying a standard threshold globally, the areas which qualify as e.g. 'high integrity' or 'intact' tend to be concentrated in certain large, remote regions. It is critical to identify and engage in global efforts to protect those highly intact ecosystems that provide the exceptional benefits outlined in Question 2. 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 a given geographical area (particularly for restoration efforts).

Section III. Ecosystem integrity in international policy

Q12: Does ecosystem integrity already appear in international policy?

A: Yes, ecosystem integrity is reflected in both international agreements (hard and soft law) and national laws and policies.

Ecosystem integrity has been referenced in several international declarations, but does not have a single multilaterally agreed definition (Bridgewater et al. 2014). It is perhaps most well-known 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 subsequently been used in intergovernmental agreements and policy fora, including, for example, the preambular text to the 1980 Convention on the Conservation of Antarctic Marine Living Resources and the 2015 Paris Agreement under the United Nations Framework on Climate Change. It has also been addressed in a more practical sense in the Operational Guidelines for the UNESCO-World Heritage Convention in 1978 (see Question 13).

Parties to the Convention on Biological Diversity (CBD), which opened for signature at the same conference where the Rio Declaration was adopted, and which now has almost universal membership, have also agreed on the importance of ecosystem integrity to nature-based solutions, including through the adoption of guidance on climate change adaptation and disaster risk reduction at CoP14 (CBD 2019). Furthermore, the maintenance of ecosystem integrity is an explicit priority in the current CBD Strategic Plan's Aichi Target 10 on vulnerable ecosystems (see Question 14).

Although not the focus of this document, it is worth noting that some countries have used ecosystem integrity as a guiding principle in national legislation or regulation, such as Canada's legislation on national parks. The *Guidelines for Identification of Key Biodiversity Areas* (the "KBA Standard"), welcomed by the IUCN World Conservation Congress in 2016, are increasingly in use at the national level to identify important sites for the persistence of biodiversity in countries such as Canada, Mozambique, Australia, Uganda, and more. The global KBA Standard has a special criterion ("Criterion C") specifically dedicated to ecological integrity (see Question 13).

Q13: Is ecosystem integrity explicitly defined in these policy frameworks?

A: Yes, in some – but while the underlying concept is consistent, specific definitions, applications, and/or thresholds may vary.

Several definitions or explanations exist across these different policy frameworks, which have slight differences in phrasing but are generally aligned with the definition outline in Question 1.

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*" (UNESCO 2019). 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*." 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*." Most recently, the UN System of Environmental Economic Accounting, adopted by the UN Statistical Commission, defined ecological integrity as, “the system’s capacity to maintain composition, structure, functioning and self-organization over time using processes and elements characteristic for its ecoregion and within a natural range of variability.” The definition has clearly become more consistent and specific over time, even though it will always be true that it will be applied through specific indicators or measurements and thresholds.

Q14: Have Parties to the CBD defined ecosystem integrity?

A: Ecosystem integrity appears both explicitly and implicitly within CBD decisions, strategic plans and agreements, but is not yet formally defined.

Ecosystem integrity was *not* defined within the Convention on Biological Diversity itself, but it has been used frequently by Parties, including in CoP decisions, strategic plans, and guidance documents. Perhaps most visibly, 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 calls for a reduction in ecosystem degradation, which can be seen as a call to retain ecosystem integrity.

Unfortunately, Aichi Targets 5 and 10 (and some others) suffer from several types of ambiguity that has led to confusion and relatively poor implementation (Butchart et al. 2016). Meanwhile, scientific research has shown that the planet is losing natural habitat, specifically 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 (CBD 2021). 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 in any new global goals and targets.

Fortunately, there has been progress in achieving this clarity through the negotiations of the post-2020 global biodiversity framework (GBF). For example, the CBD SBSTTA document that describes the scientific and technical basis for goals and targets in the GBF notes that “an ecosystem is generally understood to have integrity 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” (CBD 2020). Furthermore, the Co-Chairs of the open-ended working group on the post-2020 GBF have defined “intact areas” as “areas where there is minimal physical interference from human presence, such as fragmentation and maintaining physical integrity…and maintained all their natural ecosystem functions” (CBD 2020).

More detail on the CBD and the post-2020 GBF negotiations can be found in the following section.

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

Q15: Why is ecosystem integrity an essential component of the post-2020 global biodiversity framework?

A: Ecosystem integrity is essential for sustained conservation and sustainable use of biodiversity, as well as critical ecosystem services needed for sustainable development.

High integrity ecosystems are critical for biodiversity conservation, as many species need sufficient habitat in good condition and the presence of intact species assemblages to survive an increasing number of local and global threats (including climate change). Scientific research highlights the critical contribution of high integrity ecosystems, including highly intact ecosystems to global 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. For example, high integrity or highly intact forests contribute significantly to carbon storage and sequestration, and climate adaptation benefits (Watson et al. 2018; Martin and Watson 2016). Highly intact (and therefore highly functional) coral reefs contribute to fisheries replenishment, disaster risk reduction, and economic and food security. 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 GBF and other international goals, as requested by Parties.

Without a clear, overarching and actionable goal for retaining and, where possible, restoring ecosystem integrity, the implementation of the framework will almost certainly default to a focus on extent, and restoring extent, based on certain ecosystem attributes (e.g. forest cover) without ensuring that it remains intact and functional (resulting in, for example, empty forests without wildlife); leading to long-term declines in nature. It is therefore very urgent to improve the clarity and elevate the importance of goals and targets addressing ecosystem integrity post-2020.

Q16: Is there precedent for ecosystem integrity to be included in the CBD's global biodiversity targets?

A: Yes; most notably, ecosystem integrity was included in the Aichi Targets.

As noted above, the CBD's Aichi Biodiversity Targets, including 5 and 10, already explicitly or implicitly addressed ecosystem integrity, but suffered from ambiguity 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 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 highly intact systems for biodiversity and people, and the challenges in restoring ecosystems once they have been degraded or lost. Without a clear, overarching and actionable goal and/or target for ecosystem integrity, the implementation of existing targets will all too often default to a piecemeal manner and our assessments of national and global progress will be incomplete.

Q17: Is ecosystem integrity appropriately included in the July 2021 draft of the post-2020 global biodiversity framework and its monitoring framework?

A: Ecosystem integrity is appropriately included as a key element of ecosystem-related goals and targets in the first draft; however, the monitoring framework is currently insufficient.

Ecosystem integrity is appropriately included, and emphasized, in Goal A on the conservation of biodiversity by 2050, and it's first 2030 milestone, in the July 2021 Draft 1 of the post-2020 GBF:

> *Goal A* ***The integrity of all ecosystems is*** *enhanced, with an* ***increase of at least 15 per cent in the area, connectivity and integrity of natural ecosystems****, supporting healthy and resilient populations of all species, the rate of extinctions has been reduced at least tenfold, and the risk of species extinctions across all taxonomic and functional groups, is halved, and genetic diversity of wild and domesticated species is safeguarded, with at least 90 per cent of genetic diversity within all species maintained.*
>
> > *Milestone A.1* ***Net gain in the area, connectivity and integrity of natural systems*** *of at least 5 per cent.*

Goal A, as presented, recognizes that the concept of integrity is relevant to all ecosystems, including managed and modified ecosystems, and that Parties can measure increases or enhancements in ecosystem integrity. Furthermore, the explicit inclusion of integrity alongside the area (or extent) and connectivity of natural ecosystems is an essential objective to sustain those globally important ecosystem services address in Question 2 of this document and outline in more detail in other parts of the framework.

However, we note that the current "headline" indicators for Goal A do not sufficiently address ecosystem integrity. We call attention to the recent reviews of relevant indicators found in Nicholson et al. (in press) and Hansen et al. (2021), as well as those described in Question 10, which offer a variety of options for Parties to choose from based on ecosystem type or scale of assessment. Without clarity on how "component" or "complementary" indicators will be addressed by Parties, a failure to include a headline indicator, or indicators, clearly addressing integrity will ultimately hinder our collective ability to achieve Goal A and the 2050 Vision of the CBD.

For more detailed commentary on Draft 1 of the post-2020 GBF, please visit www.wcs.org/cbd.