ECOSYSTEM AND BIODIVERSITY CONSERVATION ACTIVITIES

Methodological document
Quantifying Biodiversity Credits

BIOCARBON CERT®

VERSION 4.0 | January 27, 2025

BIOCARBON CERT®. 2025. Ecosystem and Biodiversity Conservation Activities. Methodological document. Quantifying Biodiversity Credits. Version 4.0. BIOCARBON CERT. January 27, 2025. 54 p. ISBN 978-628-96808-3-6 (Digital). https://biocarbonregistry.com

Acknowledgments

The mathematical model for the calculation of BioCredits was developed in collaboration with Dr. Tania Oyuki Chang Martínez, Dr. Juan Felipe Charre Medellín and MCIA. Alfonso Chang Martínez. Integrating their interdisciplinary experience in ecology, conservation, mathematical modeling and applied technology for the quantification of biodiversity credits.

Table of contents

1 **Introduction** 8

2 **Objectives** 9

3 **Version and validity** 9

4 **Scope** 10

5 **Applicability conditions** 11

6 **General terms** 12

7 **Normative references** 12

8 **Terms and definitions** 13

9 **General framework** 18

10 **General requirements** 20

10.1 Geographic boundaries of the conservation initiative 20

10.2 Temporal limits and quantification periods 21

10.3 Biodiversity baseline 22

10.4 Characterization of drivers of transformation and biodiversity loss 23

10.5 Additionality analysis 24

11 **Conservation objectives and activities** 24

12 **Sampling effort** 25

13 **Metrics for the quantification of BioCredits** 25

13.1 Alpha diversity index (α) 26

13.1.1 Richness indexes 27

Specific Richness (number of species) 27

Margalef Diversity Index ($DMGj$) 28

Average alpha ($-\alpha M$) 28

13.1.2 Beta Diversity Index (β) 29
Whittaker's Index (species replacement index) 29
13.1.3 Gamma Index(γ) 29
Gamma index (Schluter and Ricklefs) 30
13.2 Structure 30
13.2.1 Proportional abundance 30
Simpson's Index ( )Dsi 30
Lambda Dominance Index (λ) 31
Shannon-Wiener equity index 31
Pielou Index ( )J' 32
13.3 Other diversity indicators 33
13.3.1 Threatened species 33
13.3.2 High Conservation Values (HCV) 36
13.4 Landscape diversity 38
13.4.1 Percentage of landscape (PLAND) 39
13.4.2 Perimeter-Area Fractal Dimension (PAFRAC) 39
13.4.3 Contagion Index (CONTAG) 40
13.4.4 Central Area Index (CAI) 41
13.4.5 Simpson's Index (SIDI) 41
14 Quantification of BioCredits 42
14.1 Metrics and range of adjusted values 42
14.2 Adjustment of the TS and HCV values 43
14.2.1 Threatened species (TS) 43
14.2.2 High Conservation Values (HCV) 43
14.3 Calculation of BioCredits 43
14.3.1 Per monitoring period 43
14.3.2 Per minimum spatial unit (MSU) 44
15 Monitoring Plan 44

16 Risk management 46

17 Uncertainty management 47

18 Permanence 47

Annex 1. Some information references 49

Annex 2. References for uncertainty analysis 52

List of tables

Table 1. Drivers of transformation and biodiversity loss 23

Table 2. Underlying causes of biodiversity loss 23

Table 3. Categories IUCN™ Red List 33

Table 4. High Conservation Values 37

Table 5. Summary of minimum and maximum limits for each of the metrics. 42

Table 6. Threatened species (EA) 43

List of figures

Figure 1. Graphical reference of Ecosystem (A.), Landscape (B.), Class (C.) y Patch (D.) 17

Figure 2. Summary and diagram of the process for obtaining BioCredits 19

Figure 3. Metrics for estimating BioCredits 27

Figure 4 . Structure of species Red List threat categories and criteria. Source IUCN. 35

Acronyms and abbreviations

BBS	BioCarbon Biodiversity Standard
CAI	Central Area Index
CDB	Convention on Biological Diversity
CONTAG	Contagion index
DMG	Margalef Diversity Index
D_{si}	Simpson Index
HCV	High Conservation Values
IUCN	International Union for Conservation of Nature
MSU	Minimum Spatial Unit
PAFRAC	Perimeter-Area Fractal Dimension
PLAND	Percentage of Landscape
SIDI	Simpson's Diversity Index (SIDI) – Landscape level
TS	Threatened species
VBC	Voluntary Biodiversity Credit

1 Introduction

Ecosystems and biodiversity are essential for providing the goods and services that support life on Earth. They play a critical role in regulating climate, mitigating extreme weather events, and sustaining livelihoods for communities worldwide. However, these ecosystems and biodiversity are facing a triple planetary crisis: climate change, loss of nature, and pollution. Human activity is the primary driver of this crisis[1].

In response to these global challenges and in line with global conservation goals[2,3], BIOCARBON CERT® has developed the BIOCARBON BIODIVERSITY STANDARD (BBS). This standard provides a comprehensive and innovative approach to the issuance of biodiversity credits, enabling the capitalization of the results of initiatives aimed at tackling pressures on biodiversity. It also promotes the conservation, restoration, and sustainable use of ecosystems as a fundamental strategy for their long-term conservation.

The BBS incorporates a landscape-based approach as an integrative unit for the design of conservation, restoration, and sustainable use strategies, adopting a holistic approach that considers various levels of biodiversity—taxa, species, populations, and communities—enabling comprehensive management of complex ecosystems. Initiative holders are required to demonstrate and quantify improvements in the abundance, diversity, integrity, and resilience of species, ecosystems, and natural processes.

Furthermore, the BBS encompasses Nature-Based Solutions (NBS), acknowledged as a pivotal component of climate action and biodiversity conservation. These solutions involve actions to protect, restore, use, and sustainably manage ecosystems. These combined efforts effectively address social and environmental challenges, providing numerous benefits such as improved human well-being, enhanced ecosystem services, and increased resilience and biodiversity[4] .

This methodological document establishes the necessary guidelines for the quantification and issuance of biodiversity credits under the BBS. Biodiversity conservation initiative holders shall adhere to these guidelines to ensure rigor,

---

[1] WWF. (2024). Living Planet Report 2024 – A System in Peril. WWF, Gland, Switzerland. ISBN: 978-2-88085-319-8.
[2] https://www.cbd.int/gbf
[3] https://www.naturepositive.org/
[4] United Nations Environment Programme (2020). The Economics of Nature-based Solutions: Current Status and Future Priorities. United Nations Environment Programme Nairobi.

transparency, and traceability in the implementation of their actions. Compliance is essential for registration and certification under the BIOCARBON STANDARD, ensuring that initiatives contribute effectively to global biodiversity conservation.

2 Objectives

This methodological document (hereinafter referred to as "METHODOLOGY") applies to the quantification of biodiversity credits, with activities developed within the framework of biodiversity conservation initiatives (hereinafter referred to as "initiatives").

In this context, this methodology:

(a) establishes the criteria for quantifying biodiversity credits, which are attributed to activities related to the conservation, ecological restoration, and sustainable use of biodiversity;

(b) outlines the methodological requirements for identifying a biodiversity baseline (BBL) for biodiversity conservation initiatives;

(c) details the methodological requirements for demonstrating that preservation, restoration, or sustainable use activities that propose to avoid biodiversity loss are additional by identifying one or more specific actions;

(d) establishes methodological requirements to demonstrate that the nature and scope of the initiatives are voluntary actions for the preservation, conservation or sustainable use of biodiversity;

(e) Describes the requirements for the monitoring and follow-up of activities for the conservation, restoration or sustainable use of biodiversity with their respective specific actions.

3 Version and validity

This document constitutes the version 4.0. January 27, 2025.

This version may be updated from time to time and intended users should ensure that they are using the latest version of the document available on the BIOCARBON website[5].

4 Scope

This METHODOLOGY corresponds to a methodology for:

(a) the definition of the geographic boundaries of biodiversity conservation areas;

(b) the identification of the biodiversity baseline;

(c) the characterization of the drivers of landscape transformation and the consequent loss of biodiversity;

(d) demonstrating the additionality of biodiversity conservation initiatives;

(e) select biodiversity conservation, restoration and sustainable use objectives;

(f) evaluate and apply valuation variables and techniques to quantify biodiversity credits.

This METHODOLOGY is limited to the following biodiversity conservation activities:

(a) *Preservation*

Actions that lead to maintaining the natura state of biodiversity and ecosystems, landscapes, by limiting or eliminating human intervention.

The specific preservation actions may include a). isolation of areas/ establishment of ecological barriers; b). isolation of forest fragments; c). surveillance and control programs; d) reduction in hunting and fishing activities.

(b) Restoration

Management processes for restoration of degraded ecosystems and prevention of future damage.

Specific restoration actions may include a). restoration of a degraded area in terms of function, structure or composition; b). restoration of the productivity and/or

[5] www.biocarbonstandard.com

ecosystem services of the original ecosystem; c). Restoring the use of the ecosystem and/or ecosystem services different from those of the original ecosystem; d). Removing the agents causing the degradation of the ecosystem.

(c) Sustainable use

Activities involving the use of components of biological diversity in a manner and at a rate that does not lead to their long-term decrease.

Specific sustainable use measures may include a) purse-seine and other control efforts; b). limitation on entry and/or actions of the public/tourists to a landscape or ecosystem; c). limitation of heavy or destructive machinery/tools and/or other forms of technology that may cause collateral damage to other elements of the landscape or ecosystem; d). recycling/rotation of soil nutrients; e). composting; f). sustainable agriculture; e). limitation of agrochemicals or fertilizers.

This METHODOLOGY shall be used by holders of biodiversity conservation initiatives to certify and register with the BIOCARBON CERT™, the initiatives under the BioCarbon Biodiversity Standard (BBS).

5 Applicability conditions

This METHODOLOGY is applicable under the following conditions.

The conservation initiative holder:

a) aims to generate sustainable use, restore or preserve the "*in situ conditions*" of biodiversity (the state at a defined point in time in quantitative and qualitative terms) and avoiding irreversible losses of biodiversity;

b) demonstrates that in situ conservation is the main objective on which the biodiversity conservation initiative activities and specific actions are based;

Conservation activities:

c) prevent the partial or total loss of an ecosystem, or land use changes;

d) prevent the loss (directly or indirectly) of a taxon, populations or species;

e) prevent the extinction of an endemic population or species of scientific, ecological or cultural value;

f) the net loss of diversity at the taxon, species or ecosystem level;

g) prevent the modification of natural systems, natural ecosystems or unique biotopes;

h) prevent the extinction of taxon, species, populations; or decrease their viability to levels that increase their risk of extinction;

i) address more than one species and habitat and are designed to support ecosystem conservation objectives at a landscape scale. This shall be done without jeopardizing the ecosystem or landscape or any of its biological components;

j) are developed in terrestrial ecosystems and some aquatic ecosystems, such as inland wetlands and mangroves.

6 General terms

The following general terms apply to this Methodology:

(a) "Shall" is used to indicate that the requirement shall be complied with;

(b) "Should" is used to indicate that, among several possibilities, one course of action is recommended as particularly suitable;

(c) "May" is used to indicate that it is permitted.

7 Normative references

The following references are indispensable for the application of this METHODOLOGY:

(a) Convention on Biological Diversity. United Nations (1992);

(b) Any applicable national policies and action plans related to the use and management of biological diversity, or those that modify or update them;

(c) Environmental legislation that dictates norms on the management of biological diversity or that which modifies or updates it;

(d) The BioCarbon Biodiversity Standard, in its most recent version;

(e) The guidelines, other orientations and/or guidelines defined by BIOCARBON CERT™ within the scope of biodiversity conservation initiatives.

8 Terms and definitions

Additionality

The conservation activities generate changes in biodiversity-related attributes and values in addition to any existing values, i.e., the conservation outcomes would not have occurred without the conservation initiative activities.

Biodiversity (Biological diversity)

The variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part: this includes diversity within species, between species and of ecosystems[6].

Biodiversity baseline

The biodiversity baseline corresponds to the complete assessment of existing conditions within the geographic boundaries of the conservation initiative prior to the initiation of conservation activities. The biodiversity baseline should be established based on the land cover present within the boundaries of the initiative, in conjunction with the evaluation of the physical and biotic components.

Biodiversity conservation initiative

Conservation activities expressly dedicated to meeting a particular objective related to biodiversity conservation. These activities should lead to the reduction of direct pressures on biological diversity and, in turn, contribute to the conservation of ecosystems.

Biodiversity Credit (BioCredit)

Corresponds to a certified unit, which represents a positive, lasting and additional biodiversity conservation outcome that would not have occurred in the absence of the project initiative. It is measured in terms of the effective reduction of threats to

[6] Convention on Biological Diversity CBD (1992). Available at https://www.cbd.int/doc/legal/cbd-en.pdf

biodiversity, prevention of anticipated losses, or enhancement of biodiversity through specific actions designed to improve ecosystem resilience.[7]

In the context of the BBS, biodiversity credits are referred to as BioCredits. The term BioCredit is accepted as a synonym for a voluntary biodiversity credit (VBC)[8]. It is a measurable, traceable and tradable unit, which represents the unit of measurement related to biodiversity conservation and is quantified through the application of the set of metrics set out in section 12 of this document.[9]

Class

Refers to categories that describe the type of surface in a landscape (e.g. forests, grasslands, agricultural areas, urban areas, water bodies, etc.). Each class represents a cover type with specific ecological properties. Each class within the landscape may be composed of one or more patches of the same class (see Figure 1 C).

Direct driver

Direct drivers of biodiversity loss are related to human activities that directly affect ecosystems. They group together factors operating at the local scale, different from the initial structural or systemic conditions, which originate in land use and affect vegetation cover through changes in land use[10].

Ecological restoration

According to the Society for Ecological Restoration (SER), ecological restoration is the process of supporting the recovery of an ecosystem that has been degraded, damaged or destroyed.[11] This process seeks to reestablish the health, integrity and sustainability of the ecosystem, promoting its capacity to maintain itself self-sufficiently over time. The actions carried out within the framework of ecological restoration guarantee the conservation of species and the continuous provision of goods and services.

---

7 Biodiversity Credit Alliance (2024). Definition of a Biodiversity Credit. Available at: https://www.biodiversitycreditalliance.org/wp-content/uploads/2024/05/Definition-of-a-Biodiversity-Credit-Rev-220524.pdf#page=5.99
8 https://www.iied.org/sites/default/files/pdfs/2022-11/21216IIED.pdf
9 International Advisory Panel on Biodiversity Credits (2024). Framework for high integrity biodiversity credit markets. Available at: https://www.iapbiocredits.org/framework
10 The term “driver”, “direct cause” is equivalent to the concept of ‘motor’ or “driver” of changes in biodiversity..
11 https://www.ser.org/

Ecosystem

A set of biological communities (e.g. plants, animals and microorganisms) interacting with each other and with the physical components of the environment and abiotic (e.g. soil, water, air), forming a dynamic system of energy flows, nutrient cycles and ecological processes[12] . An ecosystem includes Landscape.

For the application of this methodology, eligible ecosystems are terrestrial ecosystems and some aquatic ecosystems, such as inland wetlands and mangroves (see Figure 1 A)[13].

Habitat

The place or type of site where an organism or population naturally occurs.[14]

In situ conditions

The conditions where genetic resources exist within ecosystems and natural habitats, and. in the case of domesticated or cultivated species, in the surroundings where they have developed their distinctive properties[15].

In situ conservation

The conservation of ecosystems and natural habitats and the maintenance and recovery of viable populations of species in their natural surroundings and, in the case of domesticated or cultivated species, in the surroundings where they have developed their distinctive properties[16].

In situ conditions

The conditions where genetic resources exist within ecosystems and natural habitats, and. in the case of domesticated or cultivated species, in the surroundings where they have developed their distinctive properties[17].

12 CBD op. cit, p. 4
13 This methodology excludes other marine ecosystems. Like oceans, seas, estuaries, reefs, marshes and coastal lagoons, among others.
14 CDB op. Cit, p. 4
15 CDB op. Cit, p. 3
16 CDB op. Cit, p. 3
17 CDB op. Cit, p. 3

In situ conservation

The conservation of ecosystems and natural habitats and the maintenance and recovery of viable populations of species in their natural surroundings and, in the case of domesticated or cultivated species, in the surroundings where they have developed their distinctive properties[18].

Landscape

Heterogeneous spatial unit, contained within the ecosystem, and which determines the geographical limits of the initiative, in which various class types (habitats and/or land uses) are identified (see Figure 1 B).

Monitoring

Monitoring corresponds to the collection, management and archiving of the data required to apply the BioCredits quantification metrics. Monitoring should be described in a monitoring plan.

Objects of Conservation (OC)

Objects of conservation are the components of biodiversity considered in conservation activities and therefore included in the calculation of BioCredits. This includes species or taxa such as vascular or non-vascular plants, birds, amphibians, reptiles and mammals. Functional taxa, such as large herbivores or invertebrates present in the soil, may also be included. These may vary according to conservation objectives, which shall be justified by their ecological and functional relevance. When choosing their OC(s), priorities and special characteristics, such as their vulnerability status and cultural value, should be considered to ensure that their conservation contributes to the maintenance and resilience of ecosystems.

The identification of Conservation Targets should be based on the diagnosis of the functional, physical, and biotic components of the ecosystem, together with a baseline analysis, considering the local and regional context. In addition, information should be included to guarantee the stability of the ecosystems, ensuring the continuous provision of environmental goods and services.

18 CDB op. Cit, p. 3

Patch

Patches are fragments that compose a class within a landscape and are clearly differentiated from their surroundings in terms of their physical and ecological characteristics. Patches may be connected or isolated in the landscape and their shape and size may vary (see Figure 1 D).

Figure 1. Graphical reference of Ecosystem (A.), Landscape (B.), Class (C.) y Patch (D.).

Population

A population comprises individuals of the same species and a specific geographic area. Populations interact with other populations of the same type, with populations of other species and with physical aspects of their territory.

NOTE: This term is used in a specific sense in the IUCN Red List Criteria. "Population is defined as the total number of individuals of the taxon. Within the context of a regional assessment, it may be advisable to use the term global population for this. In the Guidelines the term population is used for convenience, when reference is made to a group of individuals of a given taxon that may or may not interchange propagules with other such entities"[19].

---

[19] https://portals.iucn.org/library/sites/library/files/documents/RL-2012-002-Es.pdf

Species

Species are groups of individuals or natural populations that are actually or potentially interbreeding, reproductively isolated from other similar groups by their physiological properties (producing incompatibility between parents or sterility of hybrids, or both).

Sustainable use

"Sustainable use" means the use of components of biological diversity in a way and at a rate that does not lead to the long-term decline of biological diversity, thereby maintaining its potential to meet the needs and aspirations of present and future generations[20]

Taxon

A taxon corresponds to organisms that, once described, have been assigned a scientific name (or Latin name) [21].

Underlying cause

Underlying causes are factors that reinforce the direct causes of ecosystem changes. They include social, political, economic, technological and cultural variables, which constitute the initial conditions in the existing structural relationships between human and natural systems. These factors influence the decisions made by the agents and help to explain why the phenomenon of changes in land use occurs, with the consequent loss of biodiversity.

9 General framework

This METHODOLOGY is part of BIOCARBON's Biodiversity Program, along with the Biodiversity Standard[22] . The quantification and issuance of biodiversity credits are summarized in Figure 2.

[20] https://www.cbd.int/doc/legal/cbd-en.pdf
[21] Rodríguez-Melo, M. 2022
[22] https://biocarbonstandard.com/wp-content/uploads/BCR_Estandar-Biodiversidad.pdf

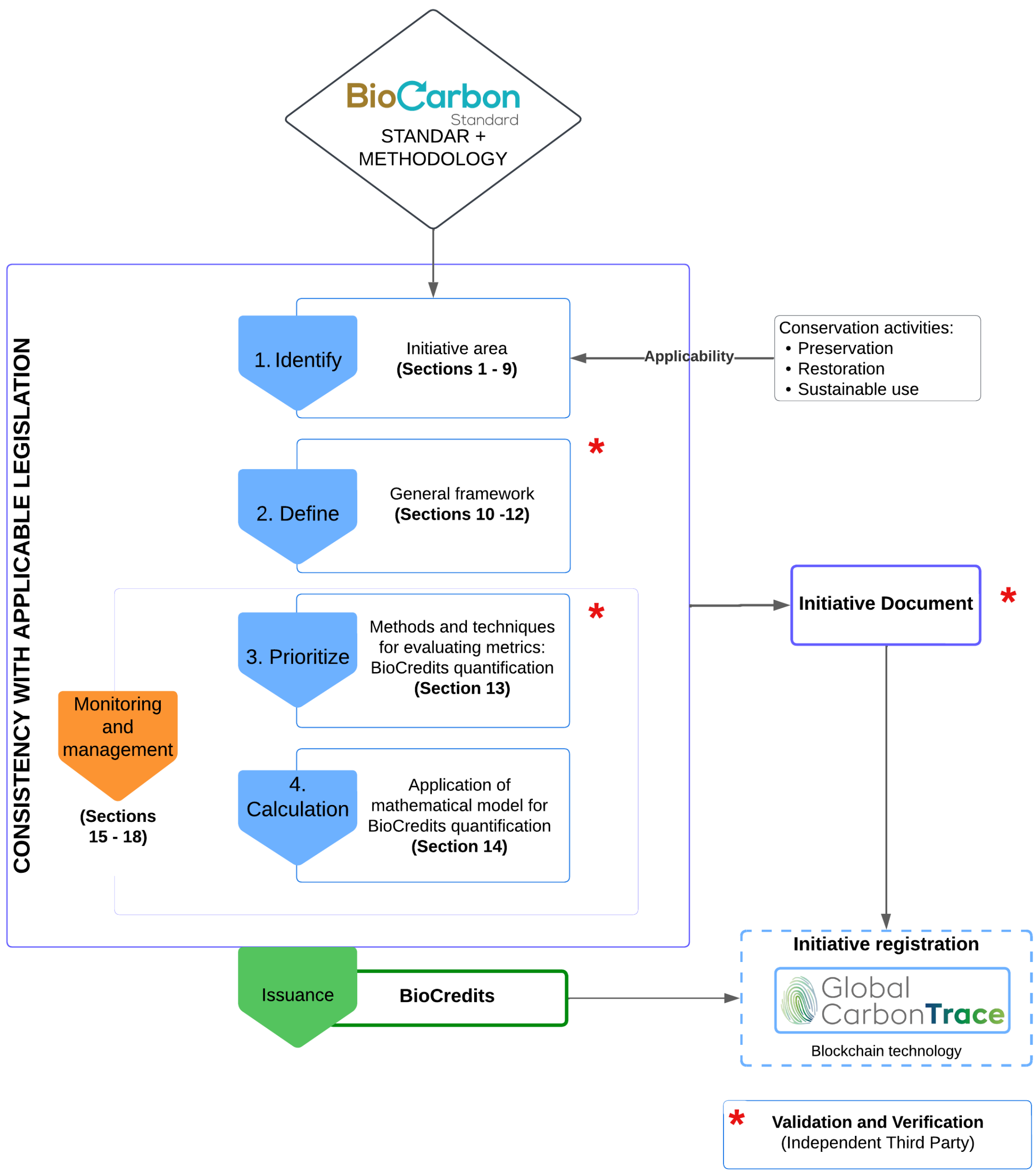

Figure 2. Summary and diagram of the process for obtaining BioCredits

10 General requirements

10.1 Geographic boundaries of the conservation initiative

The boundaries of the conservation initiative consist of the sites on which biodiversity conservation activities are carried out. The Minimum Spatial Unit (MSU) is represented in terms of surface area and corresponds to 1 hectare (10,000 m^2).

The initiative holder shall demonstrate that the areas within the geographic boundaries of the initiative correspond to the categories of vegetation or land cover considered by the land cover and land use identification system applicable to the country in which the activities of the conservation initiative are implemented[23]. The land cover identification and land use shall be carried out at a scale of 1:10,000 or higher, considering the diversity of the landscape in each MSU.

All the geographic information related to the boundaries of the conservation initiative should be represented in a Geographic Information System, for the duration of the conservation initiative. This should be done following appropriate methodologies for information systems and land cover analysis.

For example, geographic information should be handled following the quality standards of ISO 19111:2019(en)[24], which defines the conceptual schema for the description of referencing by coordinates, the minimum data required to define coordinate reference systems and the additional descriptive information (coordinate reference system metadata)

The initiative holder shall provide verifiable evidence demonstrating that the area within the boundaries of the initiative is eligible. This includes:

i. Defining the geographic boundaries of the biodiversity conservation initiative;

ii. Specify the extent and location of the areas, classified according to types of land cover and/or land use;

[23] Such as CORINE Land Cover

[24] https://www.iso.org/obp/ui#iso:std:iso:19111:ed-3:v1:en

iii. Conservation status and biodiversity in terms of ecosystem composition, structure and function.

To demonstrate the conditions, the initiative holders shall provide one of the following verifiable information alternatives:

i. Images and cartography: aerial photographs or satellite images complemented with cartographic information of references taken in the field, using validated methodologies; or,

ii. Field studies and official records: land use permits or concessions, land use plans or information from local records such as cadastre, land registry, land use or land management records; or,

iii. Participatory evaluation: In the absence of the above options, a written testimony, elaborated through participatory rural appraisal methodologies, is acceptable.

10.2 Temporal limits and quantification periods

The temporal limits of biodiversity conservation initiatives encompass the period during which conservation activities prevent the partial or total loss of an ecosystem, species, population in the area established within the geographical limits of the initiative.

The temporal limits of biodiversity initiatives shall be defined considering:

(a) The start date: the time at which activities leading to the avoidance of biodiversity loss begin;

(b) The quantification period: time during which biodiversity conservation is monitored or measured; and,

(c) Monitoring periods: Regular intervals to assess biodiversity conservation.

Biodiversity conservation initiatives may quantify BioCredits for a period of 10 years. The initiative holder may extend the period of the conservation initiative for another 10 years, justifying the reasons, objectives and expected results. The initiative holder shall evaluate the baseline conditions, additionality or other applicability conditions established by BIOCARBON and other applicable regulations.

10.3 Biodiversity baseline

The biodiversity baseline is determined through an evaluation of the structure and composition of the ecosystem. This should include the evaluation of physical and biotic aspects, as well as information related to climate and other determinants of biodiversity and landscape conditions. This assessment should be conducted for all identified land cover and/or land use types within the geographic boundaries of the initiative. The baseline makes it possible to establish the frame of reference of the conditions or state of the initiative area prior to the implementation of biodiversity conservation actions.

It is recommended to preferably use primary information, supported by valid field methodologies. If secondary information is used, it should come from official sources.

The baseline characterization shall include:

i. Detailed assessments of ecosystem structure and composition for all land cover and/or land use categories prior to the initiation of conservation initiative activities;

ii. Maps delimiting the areas according to the types of land cover and land use present;

iii. Assessment of High Conservation Values (HCV), using methodologies such as Landscape Species Approach[25] , or other appropriate methodologies.

The following sources of information can be used to establish the biodiversity baseline:

i. Aerial photographs, satellite images;

ii. Basic cartography, topographic maps, thematic cartography, geological maps, soil maps;

iii. Bibliographic documents of specific works developed in the area or zone where the biodiversity conservation initiative is located;

iv. Models based on field measurements.

[25] Wildlife Conservation Society (WCS) and Living landscape program.

10.4 Characterization of drivers of transformation and biodiversity loss

Conservation initiative holders should assess all drivers of landscape transformation and subsequent biodiversity loss. In general, the main drivers of transformation and biodiversity decline are changes in ecosystem structure and composition associated with habitat degradation. Other drivers of transformation and loss may include deforestation, forest clearing, conversion to other land uses, overexploitation of resources, mining activities, and construction of infrastructure and roads, among others

To characterize direct drivers of transformation and underlying causes, a qualitative rating matrix (Table 1) indicating the extent and frequency with which drivers of biodiversity loss have occurred should be used.

Table 1. Drivers of transformation and biodiversity loss

Driver	Extension			Frequency		
	High	Media	Low	High	Media	Low
1.						
2.						
3.						
....						
n						

In the case of underlying causes, the initiative holder shall qualitatively categorize (using Table 2) the intensity and frequency with which estimates of the underlying causes of biodiversity loss have been present.

Table 2. Underlying causes of biodiversity loss

Underlying cause	Extension			Frequency		
	High	Media	Low	High	Media	Low
1.						
2.						
3.						
....						
n						

10.5 Additionality analysis

Through the additionality analysis, the initiative holder shall demonstrate that the conservation activities lead to the protection of the ecosystem and biodiversity attributes that would not have occurred without the implementation of the initiative. Consequently, they are considered additional:

i. Activities that involve intentional and direct interventions on the landscape;

ii. Land use alternatives that do not represent use and/or coverage related to a customary activity;

Conservation activities and their specific actions should target more than one native species and be designed to support the landscape-scale conservation objectives of the original ecosystems or landscapes. This, without potentially jeopardizing that ecosystem or landscape, or any of its biological components. Therefore, the conservation initiative holder is required to establish measurable biodiversity attributes, based on reliable and credible criteria and indicators, for each biodiversity component.

11 Conservation objectives and activities

Based on the information recorded in section 10 of this document, the conservation initiative holder shall establish and justify the conservation objectives, to carry out preservation, restoration, or sustainable use activities, as well as their specific actions for each.

Conservation objectives should be directly related to High Conservation Values (HCVs), within the geographic boundaries of the initiative. The use of the *Theory of Change* (TOC) is recommended, which allows for a logical sequence of conditions and factors necessary to achieve the expected impact. With variables that allow the connections between conservation measures and biodiversity conservation to be adequately represented.

The conservation initiative holder can use the FSC Guidance for Demonstrating Impacts on Ecosystem Services[26] which includes basic elements of a theory of change and a

[26] FSC-GUI-30-006 V1-0 EN. Forest Stewardship Council® (FSC,2018). FSC®F000100.

quality checklist.

Additionally, other guidelines could be implemented. Stakeholder consultations and interviews are also crucial to identify the specific needs of local communities and indigenous peoples in terms of ecosystem and biodiversity conservation activities. This is applicable in cases where local communities and/or indigenous peoples live within the geographic boundaries of the initiative.

12 Sampling effort

Sampling effort corresponds to the size of sampling units to represent biodiversity. The maximum sampling effort relates to the size required by the sample to adequately represent the species composition of a community.

The maximum sampling effort is related to the species accumulation curves, which plot the number of species observed (vertical axis, Y-axis) versus the area or accumulated effort (horizontal axis, X-axis). The minimum area is related to the surface area at which this curve begins to be horizontal.

In this sense, these curves reach an asymptote when a sufficient representation of the biodiversity present has been achieved, and their stabilization indicates the minimum area necessary to obtain reliable results.

The holder of the biodiversity initiative shall demonstrate that it achieved the maximum sampling effort and apply appropriate techniques and tools to minimize errors and ensure the accuracy of the data collected. For example, the method described by Del Valle A.[27]

13 Metrics for the quantification of BioCredits

This METHODOLOGY presents an integral model to evaluate and quantify, with a set of metrics, the state of biodiversity. This, by means of a sequential calculation that integrates valuation indexes, both characteristics of the biological communities and of the landscape dynamics.

[27] Del Valle A, J. 1996. La asíntota de la curva especies-área como expresión de la riqueza biológica. Crónica Forestal y de Medio Ambiente. Diciembre, vol. 11, número 1. Universidad Nacional de Colombia. Colombia. Available at https://www.redalyc.org/pdf/113/11311106.pdf

The evaluation of biological communities and landscape characteristics allows the establishment of key indicators for estimating biodiversity credits, through a valuation associated with these indicators. BioCredits can be estimated considering conservation activities of terrestrial ecosystems and some aquatic ecosystems, such as inland wetlands and mangroves. This process is based on analysis techniques that value biodiversity as well as landscape quality and condition.

The estimation of biodiversity credits is based on a multi-criteria model that, through a multi-metric assessment, considers biodiversity elements such as biological and landscape communities.

Each of the metrics should be calculated according to the monitoring plan (section 14). The combination of these interrelated, but not redundant metrics[28] , allows changes in biodiversity to be identified more sensitively and accurately than univariate methods. Each metric provides specific information on the status, ecological function and resilience of ecosystems. They should all be calculated for each monitoring period in which biodiversity and landscape conservation can be demonstrated and quantified (Annex 1).

The application of this multi-criteria assessment recognizes the interconnectedness between the various landscape elements and biodiversity conservation conditions. In this way, the METHODOLOGY ensures a rigorous and verifiable quantification of biodiversity conservation credits, in accordance with established best practices for landscape and biodiversity conservation assessment (Figure 3).

13.1 Alpha diversity index (α)

Alpha diversity is the species richness in a community that is considered homogeneous, representing richness at the local level. Under this methodology, the assessment should be made at the level of a "landscape unit" (according to the definitions in section 12.4).

To measure alpha diversity, there are several indices related to the number of species (richness) or to structural data, such as abundances and dominances.

[28] Two variables are redundant when they indirectly provide the same information.

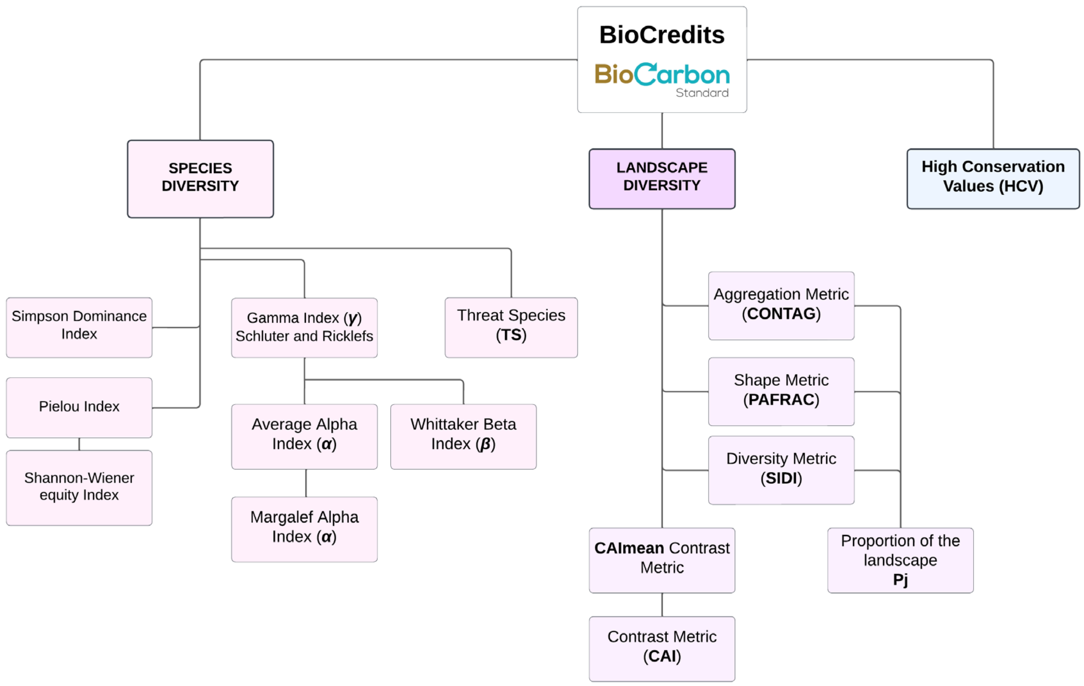

Figure 3. Metrics for estimating BioCredits

13.1.1 Richness indexes

Specific Richness (number of species)

The simplest way to determine richness is the number of species per sampling site. Specific richness is used to determine the number of species present in the ecosystem. It refers to the total number of species in an area, without considering the abundance of each species. It is calculated with the Equation 1.

$$D_{riqueza} = S \qquad \text{Equation 1}$$

Donde:

$D_{riqueza}$	=	Specific richness
S	=	Total number of species identified

Margalef Diversity Index (D_{MG_j})

It is a measure of specific diversity. It relates the number of species to the total number of individuals. In general, values below 2.0 represent areas with low biodiversity; values above 5.0 are considered indicative of high biodiversity.

This index is based on the number of species and their abundances, observed in the different classes present in the landscape. Classes refer to the different categories that describe the type of surface in a landscape (e.g. forests, grasslands, agricultural areas, urban areas, water bodies, etc.). The diversity index is calculated using Equation 2.

$$D_{MG_j} = \frac{S-1}{\ln(N)} = \alpha_{M_j} \qquad \text{Equation 2}$$

Where:

D_{MG_j}	=	Margalef diversity index in class *j*
S	=	Total number of species
N	=	Number of individuals
$\overline{\alpha_M}$	=	Average alpha of the entire landscape (numerical)

Average alpha ($\overline{\alpha_M}$)

With the result of the Margalef Index for the *j* classes (α_{M_j}), the alpha biodiversity at landscape level is defined as average alpha ($\overline{\alpha_M}$). It is estimated by generating an average of the Margalef Indices obtained for each *j* classes. The average alpha is calculated with the Equation 3.

$$\overline{\alpha_M} = \sum_{j=1}^{NC} \frac{\alpha_{M_j}}{NC} \qquad \text{Equation 3}$$

Where:

$\overline{\alpha_M}$	=	Average alpha of the entire landscape (numeric)
α_{M_j}	=	Margalef index by class *j*
NC	=	Total number of classes

13.1.2 Beta Diversity Index (β)

The degree of species turnover is mainly evaluated by considering proportions or differences. Proportions can be determined with the help of indices and/or coefficients that indicate how similar or dissimilar two communities or samples are.

Similarity or dissimilarity expresses the degree of similarity in species composition and their abundances in two samples.

Thus, beta diversity is a measure used to evaluate the variation in species composition among different landscapes or classes. This index is based on the ratio of species diversity in a class to the total species diversity in a landscape. A high value indicates that there is a greater difference in species composition between the classes compared, while a low index suggests that the communities are more similar.

Whittaker's Index (species replacement index)

The Whittaker index is a measure used to assess beta diversity, i.e., the variation in species composition among different classes. This index is based on the ratio of species diversity at a specific site to the total species diversity within the landscape. It is calculated using Equation 4.

$$\beta = \frac{S}{\bar{\alpha}_M} - 1 \qquad \text{Equation 4}$$

Where:

β	=	Beta Diversity
S	=	Total number of species
$\bar{\alpha}_M$	=	Average alpha of the entire landscape

13.1.3 Gamma Index(γ)

It is a measure related to species diversity. It is used to evaluate the total diversity in the landscape, taking as parameters both alpha diversity (α) and beta diversity (β), total species richness existing in a larger area. Gamma diversity is the sum of alpha diversity in all landscape units within the geographic boundaries of the initiative.

Gamma index (Schluter and Ricklefs)

The gamma index (γ) is a measure used to evaluate the total diversity in the landscape, taking both alpha diversity (average alpha) and beta diversity (β) as parameters. In other words, the gamma index represents the total diversity of species in a set of classes or in the landscape. It is calculated using Equation 5.

$$\gamma = \left(\overline{\alpha_M}\right)(\beta)(NC) \qquad \text{Equation 5}$$

Where:

γ	=	Gamma Index
β	=	Beta diversity (α) (result of Equation 4)
$\overline{\alpha_M}$	=	Average alpha of the whole sample (see equation 3)
NC	=	Total number of classes in the landscape

13.2 Structure

13.2.1 Proportional abundance

Classified as dominance and equity indexes since they consider the number of individuals per species.

Simpson's Index ( )D_{si}

This index measures the richness of organisms in landscape units. It is useful for evaluating how the dominance of certain species affects the state of biodiversity in an area. Simpson's index takes as a parameter the number of individuals per species in the landscape. It is calculated using Equation 6.

$$D_{si} = \sum_{i=1}^{S}\left(\frac{n_i^2 - n_i}{N^2 - N}\right) \qquad \text{Equation 6}$$

Where:

D_{si}	=	Simpson's Index
n_i	=	Number of individuals of the same species
N	=	Total number of individuals in the landscape
S	=	Total number of species

Simpson's diversity index determines the probability that two individuals taken at random from a sample are of the same species. Therefore, this is a probability value. It ranges from 0 to 1. A high value (close to 1) indicates that the community is dominated by one or a few species. While a low value of (close to 0) suggests that the species are evenly distributed. Values close to zero represent higher diversity, and values close to 1 represent lower diversity.

Lambda Dominance Index (λ)

The Lambda Dominance Index (λ) is a metric that quantifies the level of dominance in a community, based on the proportion of individuals of each species with respect to the total number of species.

This index is useful for detecting inequality in the distribution of abundances among species, highlighting the preeminence of dominant species. It is conceptually equivalent to Simpson's Index (D). However, some interpretations distinguish the use ofλ specifically to highlight dominance, while$D$ can be interpreted as a more general metric of diversity. The range of values is from 0 to 1 where a value closer to 1 reflects greater equity and diversity, while values close to 0 indicate lower diversity. It is calculated using Equation 7.

$$D_{\lambda} = 1 - D_{si}$$ Equation 7

Where:

D_{λ}	=	Lambda Dominance Index
D_{si}	=	Simpson's Index

Shannon-Wiener equity index

The Shannon-Weiner equity index, also known as the Shannon Diversity Index, is a measure used to quantify species diversity in the landscape.

This index estimates species abundance under the assumption that all species are represented in the samples and that all individuals were randomly sampled. This index considers not only the number of species present (richness), but also the distribution of individuals among these species (evenness). It is calculated using Equation 8.

$$H' = -\sum_{i=1}^{S}((p_i)(lnp_i))$$ Equation 8

$$p_i = \frac{n_i}{N}$$

Where:

H'	=	Shannon-Wiener Index
p_i	=	Proportional abundance, i.e., the number of individuals of the species among the total number of individuals in the landscape.
S	=	Total number of individuals in the landscape
n_i	=	Total number of individuals of the same species per landscape
N	=	Total number of individuals per landscape

Pielou Index ( )J'

The Pielou index, also known as Pielou's equity index (J') is a measure used to evaluate the equity in the distribution of individuals among species in a class.

This index is based on the Shannon-Wiener diversity index and provides a way to understand how individuals are distributed among different species. That is, based on the values of the Shannon-Wiener index, the Pielou index represents a relationship between the observed diversity and the maximum expected diversity value.

It expresses equity as the ratio of observed diversity to the maximum expected diversity. It takes values between 0 and 1. Values close to 0 indicate an uneven distribution in species abundance, with one or a few species dominating the community. While values close to 1 indicate a very equal distribution of individuals among species. It is calculated with the Equation 9.

$$J' = -\frac{H'}{H'_{max}} \qquad \text{Equation 9}$$

$$H'_{max} = lnS$$

Where:

J'	=	Pielou Index (equity)
H'	=	Shannon-Wiener Diversity Index
H_{max}	=	Maximum value of Shannon index
S	=	Total number of species

13.3 Other diversity indicators

The presence of threatened species and High Conservation Values (HCV) complement the assessment of diversity indices (composition and structure), calculated at the geographic boundaries of the conservation initiative (landscape).

13.3.1 Threatened species

The holder of the conservation initiative demonstrates that globally threatened species (according to the IUCN Red List™)[29] are present in its geographic boundaries and that develops actions aimed at conserving these species.

"*The IUCN Red List of Threatened Species™ is the world's most comprehensive information source on the global extinction risk status of animal, fungus and plant species. It is based on an objective system for assessing a species' risk of extinction if conservation action were not taken*" [30].

According to IUCN,[31] "*More than 41,000 species are threatened with extinction. That is still 28% of all assessed species*". Consequently, determining whether species under some degree of threat are found within the geographic limits of biodiversity conservation initiatives makes it possible to link conservation actions with reducing pressures on species to prevent extinction processes.

The categories defined by the IUCN relate the risk of extinction to a certain degree of threat. The categories are found in Table 3.

Table 3. Categories IUCN™ Red List

Categories	Symbol	Definition
EXTINCT	EX	A taxon is Extinct when there is no reasonable doubt that the last individual has died. A taxon is presumed Extinct when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle

[29] https://www.iucnredlist.org/

[30] UICN. (2012). IUCN. (2012). IUCN Red List Categories and Criteria: Version 3.1. Second edition. Gland, Switzerland and Cambridge, UK: IUCN. iv + 32pp. Available at: https://portals.iucn.org/library/sites/library/files/documents/RL-2001-001-2nd.pdf

[31] https://www.iucnredlist.org/es/

Categories	Symbol	Definition
		and life form.
EXTINCT IN THE WILD	EW	A taxon is Extinct in the Wild when it is known only to survive in cultivation, in captivity or as a naturalized population (or populations) well outside the past range. A taxon is presumed Extinct in the Wild when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form.
CRITICALLY ENDANGERED	CR	A taxon is Critically Endangered when the best available evidence indicates that it meets any of the criteria A to E for Critically Endangered (see Section V), and it is therefore considered to be facing an extremely high risk of extinction in the wild.
ENDANGERED	EN	A taxon is Endangered when the best available evidence indicates that it meets any of the criteria A to E for Endangered (see Section V), and it is therefore considered to be facing a very high risk of extinction in the wild.
VULNERABLE	VU	A taxon is Vulnerable when the best available evidence indicates that it meets any of the criteria A to E for Vulnerable (see Section V), and it is therefore considered to be facing a high risk of extinction in the wild.
NEAR THREATENED	NT	A taxon is Near Threatened when it has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future.
LEAST CONCERN	LC	A taxon is Least Concern when it has been evaluated against the criteria and does not qualify for Critically Endangered, Endangered, Vulnerable or Near Threatened. Widespread and abundant taxa are included in this category
DATA DEFICIENT	DD	A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution are lacking. Data Deficient is therefore not a category of threat. Listing of taxa in this category indicates that more information is required and acknowledges the possibility that future research will show that threatened classification is appropriate. It is important to make positive use of whatever data are available. In many cases great care should be exercised in choosing between DD and a threatened status. If the range of a taxon is suspected to be relatively circumscribed, and a considerable period of time has elapsed since the last record of the taxon, threatened status may well be justified.

Categories	Symbol	Definition
NOT EVALUATED	NE	A taxon is Not Evaluated when it has not yet been evaluated against the criteria.

Source: IUCN RED LIST CATEGORIES AND CRITERIA[32]

In the IUCN document there is a description of the nature of the categories, as follows:

"*Extinction is a chance process. Thus, a listing in a higher extinction risk category implies a higher expectation of extinction, and over the time-frames specified more taxa listed in a higher category are expected to go extinct than those in a lower one (without effective conservation action). However, the persistence of some taxa in high-risk categories does not necessarily mean their initial assessment was inaccurate.*

All taxa listed as Critically Endangered qualify for Vulnerable and Endangered, and all listed as Endangered qualify for Vulnerable. Together these categories are described as 'threatened'. The threatened categories form a part of the overall scheme. It will be possible to place all taxa into one of the categories".

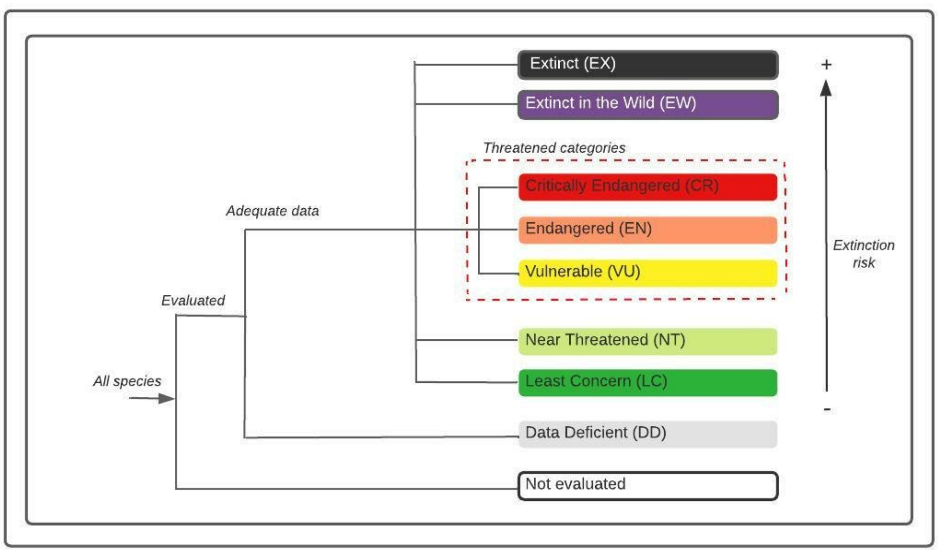

Figure 4 . Structure of species Red List threat categories and criteria. Source IUCN.[33]

[32] https://portals.iucn.org/library/sites/library/files/documents/RL-2001-001-2nd.pdf
[33] Op. cit. p. 5

The result of the endangered species assessment should be a list of species present within the geographic boundaries of the conservation initiative, where the risk category is established.

If a species is not on the IUCN Red List, other national, regional or local databases may be used, mentioning the sources of information used to define the species' threat criteria.

For the calculation of threatened species, the value corresponding to each risk category according to Table 3 shall be considered, and the values of the risk categories for which there is at least one species recorded in the landscape or geographic limits of the initiative are added together. In the equation for obtaining credits, these are represented by the acronym TS (Threatened Species).

13.3.2 High Conservation Values (HCV)

The holder of the conservation initiative shall demonstrate that High Conservation Values (HCVs) are present in the initiative area[34]. According to the HCV network, "*an HCV is an exceptionally significant or critically important biological, ecological, social or cultural value.*"

Holders of biodiversity conservation initiatives should submit a rigorous assessment of HCVs, interpreting the results based on the precautionary principle[35]. To conduct the HCV assessment, it is recommended to use what is described in the FSC Standard version 5.0 (Principle 9: high conservation values)[36].

The identification of HCVs consists of interpreting what the HCV definitions mean in the conservation initiative area and demonstrating that they are represented in the conservation initiative sites (Table 4).

[34] The concept of High Conservation Value (HCV) was defined by the Forest Stewardship Council - FSC (1996) in its Principles and Criteria. Currently, HCVs are based on the criteria defined by the High Conservation Value (HCV) network. https://www.hcvnetwork.org/

[35] Principle 15. Rio Declaration on Environment and Development. Available at: https://www.cbd.int/doc/ref/rio-declaration.shtml

[36] https://connect.fsc.org/document-centre/documents/resource/392

Table 4. High Conservation Values

HCV 1	Species diversity. Concentrations of biological diversity including endemic species, and rare, threatened or endangered* species that are significant at global, regional or national levels.
HCV 2	Landscape-level ecosystems and mosaics. Intact forest landscapes and large landscape-level ecosystems and ecosystem mosaics that are significant at global, regional or national levels, and that contain viable populations of the great majority of the naturally occurring species in natural patterns of distribution and abundance.
HCV 3	Ecosystems and habitats. Rare, threatened, or endangered ecosystems, habitats or refugia.
HCV 4	Critical ecosystem services. Basic ecosystem services in critical situations, including protection of water catchments and control of erosion of vulnerable soils and slopes.
HCV 5	Community needs. Sites and resources fundamental for satisfying the basic necessities of local communities or Indigenous Peoples (for livelihoods, health, nutrition, water, etc.), identified through engagement with these communities or Indigenous Peoples.
AVC 6	Cultural values. Sites, resources, habitats and landscapes of global or national cultural, archaeological or historical significance, and/or of critical cultural, ecological, economic or religious/sacred importance for the traditional cultures of local communities or Indigenous Peoples, identified through engagement with these local communities or Indigenous Peoples.

Source: BioCarbon, 2025[37]

All of this is done through an HCV assessment, which consists of stakeholder consultation, analysis of existing information and collection of additional information where necessary.

HCV assessments should result in a clear report of the presence or absence of values, their location, status and condition, and to the extent possible should provide information on habitat areas, essential resources, and critical areas that maintain those values. This will be used to develop management recommendations to ensure that HCVs are maintained or even enhanced.

To obtain the HCV value, the sum of the identified category or categories is calculated by assigning the value (Table 4) identified within the ecosystem. It is calculated using the Equation 10.

[37] Based on FSC. Available at: https://connect.fsc.org/document-centre/documents/resource/392

$$AVC_{total} = \sum AVC \qquad \text{Equation 10}$$

Where:

AVC = High Conservation Value (HCV) Categories

13.4 Landscape diversity[38]

Landscape ecology addresses the interactions between the spatial patterns of ecosystems and the ecological processes occurring within them. This approach evaluates how landscape structure and composition influence species distribution and abundance, as well as ecosystem dynamics.

A key concept in this assessment is that of *landscape patches*, which refers to the combination of different types of habitats and ecosystems present in an area. These patches include forests, grasslands, water bodies, urban areas and other cover types. The arrangement and connectivity of these elements determine species mobility, resource availability and, in general, the ecological functionality of the landscape.

Landscape ecology is also concerned with the effects of human activities, such as agriculture, urbanization and deforestation, on the structure and composition of natural landscapes. These changes can fragment habitats, reduce biodiversity and alter key ecological processes.

In this context, the assessment of landscape diversity is essential to understand how the different components interact with each other and how these interactions affect biodiversity and ecosystem integrity.

Landscape diversity should be calculated from a land cover and land use map, classifying each type of cover or use within the conservation initiative area. To estimate landscape indices, the use of spatial modeling tools such as FragScape, Fragstat, GRASS GIS, Patch Analyst, V-Late or other appropriate models that allow for the quantification of landscape metrics is recommended.

When analyzing landscape diversity, the following aspects should be considered:

---

[38] Descriptions and equations based on and modified from Fragstats. Available at: https://www.fragstats.org/index.php/documentation

(a) Landscape Composition: Refers to the variety and abundance of classes, patches and ecosystems present in the landscape. This component focuses on identifying which elements are present and in what relative proportion (Figure 1).

(b) Landscape Structure: Refers to the spatial organization of patches and cover categories within the landscape, as well as the spatial relationships between them. Structure includes metrics such as connectivity, shape and size of patches, as well as distances between them and their configuration in space.

Understanding and monitoring landscape diversity allows us to identify key areas for conservation, assess the impacts of human activities, and design strategies to maintain or restore the ecological functionality of ecosystems in the context of conservation initiatives.

13.4.1 Percentage of landscape (PLAND)

Landscape percentage quantifies the proportional abundance of each patch type in each area. Like total class area, this measure is crucial for understanding landscape composition in various ecological applications. However, because PLAND is a relative measure, it is more appropriate for comparing landscape composition between areas of different sizes than class area.

PLAND approaches 0 when the corresponding class becomes progressively scarce in the landscape. PLAND = 100 when the entire landscape is composed of a single patch type; that is, when a single class is present. It is calculated using Equation 11.

$$\text{PLAND} = P_j = \frac{\sum_{k=1}^{NP}(a_{kj})}{lnA} \qquad \text{Equation 11}$$

Where:

P_j	=	Portion of landscape occupied by class *j* (decimals)
a_{kj}	=	Area of patch k of class j (m^2)
A	=	Total landscape area (m^2)

13.4.2 Perimeter-Area Fractal Dimension (PAFRAC)

It is a metric that describes the complexity of patch shapes in a landscape, evaluating the relationship between the perimeter and the area of a patch. This metric provides information on the heterogeneity of the landscape and on ecological dynamics, such as habitat fragmentation and connectivity between patches. It is calculated with the Equation 12.

Equation 12

$$PAFRAC = \frac{2}{\frac{\left[NP \ \sum_{j=1}^{NC} \sum_{k=1}^{NP} \left(ln\ (p_{kj})\right)\left(ln(a_{kj})\right)\right] - \left[\sum_{j=1}^{NC} \sum_{k=1}^{NP} \left(ln\ (p_{kj})\right)\left(\sum_{j=1}^{NC} \sum_{k=1}^{NP} \left(ln\ (a_{kj})\right)\right)\right]}{\left(\sum_{k=1}^{NP} \left(ln\ (p_{kj})\right)^2\right) - \left(\sum_{k=1}^{NP} \left(ln\ (a_{kj})\right)\right)^2}}$$

Where:

$PAFRAC$	=	Fractal dimension of perimeter-area
a_{kj}	=	Area of patch k of class j (m²)
p_{kj}	=	Perimeter of patch k of class j (m)
NP	=	Total number of patches in the landscape
NC	=	Total number of classes in the landscape

13.4.3 Contagion Index (CONTAG)

The Contagion Index is a measure used in landscape ecology and planning to assess the spatial distribution of patch types within a landscape. This index indicates the tendency of a patch type to be associated with other patches of the same type. A high value suggests that patches of the same type are clustered together, which may have implications for habitat connectivity and biological diversity. Conversely, a low value indicates a greater dispersion of patches, which may affect species dynamics and ecosystem resilience. It is calculated with the Equation 13.

Equation 13

$$CONTAG = 1 + \frac{\sum_{m=1}^{NC} \sum_{n=1}^{NC} \left[P_j \left(\frac{g_{mn}}{\sum_{j=1}^{NC} g_{mj}}\right)\right] \left[ln\ P_j \left(\frac{g_{mn}}{\sum_{j=1}^{NC} g_{mj}}\right)\right]}{2 \ln NC}$$

Where:

$CONTAG$	=	Contagion rate
P_j	=	Portion of the landscape occupied by the class (equation 14)
g_{mn}	=	Number of adjacencies between patches m and n
NC	=	Total number of classes in the landscape

13.4.4 Central Area Index (CAI)

A measure used to describe the quality and integrity of a habitat in each area or landscape patch. This index helps assess the amount of "core area" within a patch, which is generally considered the part of the habitat that is least susceptible to negative edge effects (such as invasion by non-native species, increased predation, or more extreme temperature fluctuations). The CAI at the patch level is calculated using Equation 14.

$$CAI_k = \frac{a_{kj}^{core}}{a_{kj}}(100) \quad \text{Equation 14}$$

Where:

CAI	=	Central area index (percentage)
a_{kj}^{core}	=	Central area of patch k of class j (m²). Core corresponds to the central area (core or center) and k (patch) of the classes j
a_{kj}	=	Area of patch k of class j (m²)

Once the values at the patch level have been determined, we will proceed to calculate the **average core area index** (CAI_{mean}), which is a measure that describes the average amount of core area within a set of patches or habitat fragments in a landscape. In other words, it is the average value of the percent core area of several patches when the core area index (CAI) is calculated for each patch. It is calculated with the Equation 15.

$$CAI_{mean} = PromCAI_k \quad \text{Equation 15}$$

Where:

CAI_{mean}	=	Average Central Area Index (landscape level)
CAI_k	=	Central area index (patch level)

13.4.5 Simpson's Index (SIDI)

This index focuses on the proportion of different types of patches and is less sensitive to the presence of rare types of patches, making it a useful option when you want to assess overall diversity without rare types influencing the result too much.

The value of Simpson's index represents the probability that, when selecting two pixels at random from a given landscape, they correspond to different types of classes. A higher value indicates greater diversity, suggesting a richer variety of classes in the landscape, while a lower value suggests that the landscape is dominated by few. It is calculated with the Equation 16.

$$SIDI = \sum_{j=1}^{NC} P_j^2$$ Equation 16

Where:

$SIDI$	=	Simpson's Index
P_j	=	Proportion of the landscape occupied by class *j* (decimals)

Simpson's diversity index has a range of values that varies between 0 and 1, in this case it is presented in inverted form (D = 1 - Simpson's index) to facilitate interpretation.

14 Quantification of BioCredits

The initiative holder shall demonstrate and quantify biodiversity conservation outcomes using the metrics described in section 13 (species and landscape diversity). These calculations shall reflect the sustained enhancement or maintenance of biodiversity, as well as the resilience and health of ecosystems within the geographic boundaries of the conservation initiative.

14.1 Metrics and range of adjusted values

Once the values of the previously described indicators have been obtained, they shall be adjusted to fall within the ranges established for each metric (Table 5).

Table 5. Summary of minimum and maximum limits for each of the metrics.

Indicator	Limits	Adjustment	Adjusted limits
Gamma index (γ)	$0 < \gamma < \infty$	No adjustment	$0 < \gamma < \infty$
Lambda dominance (D_λ)	$0 < D_\lambda < 1$	No adjustment	$0 < D_\lambda < 1$
Pielou Index (J')	$0 < J' < 1$	No adjustment	$0 < J' < 1$
Perimeter-Area Fractal Dimension (PAFRAC)	$1 < \text{PAFRAC} < 2$	$\text{PAFRAC} - 1$	$0 < \text{PAFRAC} < 1$
Contagion index (CONTAG)	$0 < \text{CONTAG} < 100$	$\frac{contag}{100}$	$0 < \text{CONTAG} < 1$
Average central area index CAI_{mean}	$0 < CAI_{mean} < 100$	$\frac{CAI_{mean}}{100}$	$0 < CAI_{mean} < 1$

Indicator	Limits	Adjustment	Adjusted limits
Simpson's Index (SIDI)	$0 < SIDI < 1$	No adjustment	$0 < SIDI < 1$

Fuente: BioCarbon, 2025

14.2 Adjustment of the TS and HCV values

The following tables are used for the values designated for Threatened Species (TS) and High Conservation Values.

14.2.1 Threatened species (TS)

For Threatened Species (TS), the sum of the different categories present in the ecosystem is applied (Table 6).

Table 6. Threatened species (EA)

Category	Symbol	Value
Critically Endangered	EN	5
Vulnerable	VU	4
Near Threatened	NT	3
Minor Concern	LC	2
Insufficient Data	DD	1
Not Evaluated	NE	1

14.2.2 High Conservation Values (HCV)

For High Conservation Values (HCV) (numeral 12.3.2), the six HCV categories are considered (Table 4) with adjustment by a value of two (2) for all categories. If one or more categories are identified, present within the ecosystem, they are summed.

14.3 Calculation of BioCredits

14.3.1 Per monitoring period

Biodiversity credits, by monitoring period, are calculated using Equation 17.

$$BioCredits = \frac{\left[\sum_{OC=1}^{OC=n} \frac{(\gamma)[TS]}{1-\left(\frac{D_\lambda + J'}{2}\right)}\right][HCV_{total}]}{1-\left(\frac{PAFRAC + CONTAG + CAI_{mean} + SIDI}{4}\right)}$$ Equation 17

Where:

$BioCredits$	=	Voluntary Biodiversity Credits
γ	=	Gamma index
TS	=	Threatened species
D_λ	=	Lambda dominance
J'	=	Pielou Index
HCV	=	High Conservation Values
PAFRAC	=	Fractal dimension of perimeter-area
CONTAG	=	Contagion index
CAI_{mean}	=	Average central area index
SIDI	=	Simpson's Index (landscape)
OC	=	Object of Conservation

14.3.2 Per minimum spatial unit (MSU)

The BioCredits calculated during the monitoring period, per Minimum Spatial Unit, are calculated using Equation 18.

$$BioCredits_{MSU} = \frac{Biocredits_{mp}}{A}$$ Equation 18

Where:

$BioCrredits_{UEM}$	=	BioCredits, per minimum spatial unit; ha
$BioCredits_{mp}$	=	BioCredits, per monitoring period; no dimension
A	=	Area of the conservation initiative; ha

15 Monitoring Plan

As part of the conservation initiative document (CID), initiative holders shall submit a monitoring plan that, at a minimum, contains the following:

(a) the data and information necessary to calculate biodiversity credits;

(b) data and complementary information to determine the biodiversity baseline;

(c) information related to risk assessment and risk management;

(d) the procedures established for managing the results of biodiversity credits and related quality control for monitoring activities;

(e) description of the procedures defined for the periodic calculation of biodiversity credits;

(f) the assignment of roles and responsibilities for monitoring and reporting of variables relevant to the estimation of biodiversity credits

(g) the procedures related to the evaluation of the contribution of the biodiversity conservation initiative to the Sustainable Development Goals (SDGs);

(h) the necessary procedures to follow up on climate change adaptation strategies;

(i) the criteria and indicators related to the initiative's contribution to sustainable development objectives, applicable to the activities proposed by the initiative's owner;

The monitoring plan should be structured appropriately and in accordance with:

(a) national circumstances and the context of the biodiversity conservation initiative;

(b) good monitoring practices, appropriate for the follow-up and control of the activities of the biodiversity conservation initiative;

(c) procedures to ensure the quality of the data.

Additionally, the monitoring plan should provide for the collection of all relevant data necessary to:

(a) verify that the applicability conditions listed in section 5 of this document have been met;

(b) check for changes from baseline conditions associated with the activities of the conservation initiative;

(c) to follow up on the risks identified and their proper management;

(d) the contribution of the biodiversity conservation initiative to the Sustainable Development Goals (SDGs);

(e) compliance with the Sustainable Development Safeguards (SDGs);

(f) monitoring climate change adaptation strategies.

The monitoring plan shall include the follow-up of qualitative and quantitative indicators associated with the structure, composition and functionality of the ecosystems, and other variables of analysis, including the description of the indicator, the unit of measurement, as well as the periodicity and the person responsible for the measurement.

The proposed indicators should be consistent with the baseline data collection, the objective of which is to monitor the results of conservation activities, as well as the evaluation of proposed conservation activities and adaptation strategies.

The holder of the biodiversity conservation initiative may determine the periodicity of monitoring, considering its Conservation Objective(s) and the design for the application of quantification metrics. However, monitoring periods should never exceed five (5) years, or less than 1 year.

16 Risk management

The owners of biodiversity conservation initiatives shall assess the risks related to the implementation of conservation activities, environmentally, financially and socially.

Based on the identification of risks in these three dimensions, the initiative holder shall design measures to manage the risks so that the quantification of biodiversity credits remains similar or higher during and after the duration of the initiative's conservation activities.

In this regard, the holder of the biodiversity conservation initiative should:

(a) determine the context, defining the scope and criteria required for risk management;

(b) identify potential natural and anthropogenic risks to which conservation actions may be exposed and determine the necessary measures to mitigate such risks;

(c) identify potential financial risks related to expected costs and investments, as well as the cash flows of the conservation initiative and define the necessary measures to mitigate financial risks;

(d) determine, in the medium and short term, the risks associated with the participation of local communities and stakeholders in the activities proposed in the biodiversity conservation initiative;

(e) quantify the risk in each of the components described above.

The owner of the conservation initiative should employ appropriate methodologies to carry out the assessment of expected risks (direct and indirect) and consider mitigation measures, within the framework of adaptive management.

Adaptive management is a process by which conservation activities and their specific actions can be adapted to future conditions to ensure the achievement of the proposed objectives. It is a structured decision-making process that considers the variables of incidence with the objective of reducing uncertainty about the results.

The conservation initiative holder should include a summary of risks and management actions in a matrix/table outline, referencing a specific plan or procedure in the initiative's action plan.

17 Uncertainty management

The conservation initiative holder shall take uncertainty into account by documenting the sources of information, the consistency and relevance of the data and the results related to the quantification of biodiversity credits.

An uncertainty analysis should be carried out using an appropriate model and justifying the choice of variables related to the assessment (Annex 2).

18 Permanence

Within the framework of compliance with the conservation objectives and activities and specific actions proposed, the initiative's holder shall demonstrate that the initiative's implementation has a legal and financial basis that guarantees its execution in the medium and long term.

Appropriate management of the elements that make up the long-term viability of conservation initiatives includes, but is not limited to, the following:

(a) Legal and institutional frameworks (as well as compliance with them), as adequate instruments for minimizing risks associated with the permanence of the conservation initiative's activities;

(b) Defined roles and responsibilities for the execution and monitoring of conservation activities;

(c) Legal framework that includes rigorous agreements that guarantee the recognition of rights over biodiversity credits;

(d) Rigorous, demanding and quality assurance during the process of registration and issuance of biodiversity credits;

(e) Supervision, monitoring and management of biodiversity conservation initiative activities.

Annex 1. Some information references

Non-exclusive guidance is provided on methods and techniques for biodiversity and landscape information gathering. The nature of science and methodological approaches requires that the methods and techniques used be updated and adapted as tools and available knowledge evolve. Therefore, it is essential to maintain flexibility and adapt strategies to the specific needs of scientific initiatives and advances.

If the initiative holder has more precise equipment or techniques, these are also valid, as long as they are used consistently and systematically during the monitoring periods. Here are some references for biodiversity and landscape monitoring techniques and methods.

Biodiversity monitoring	Hill, D.; Fasham M., Tucker G., Shewry M, Shaw P. (2005). *Handbook of biodiversity methods: Survey, evaluation and monitoring*. Cambridge University Press.
	Nicholson, E.; Watermeyer, KE.; Rowland, JA.; Sato, CF.; Stevenson, SL.; Andrade, A.; Brooks, TM.; Burgess, ND.; Cheng, ST.; Grantham, HS.; Hill, SL.; Keith, DA.; Maron, M.; Metzke, D.; Murray, NJ.; Nelson, CR.; Obura, D.; Plumptre, A.; Skowno, AL.; Watson, JEM. (2021). Scientific foundations for an ecosystem goal, milestones and indicators for the post-2020 global biodiversity framework. *Nat Ecol Evol* 5(10), 1338-1349. https://doi.org/10.1038/s41559-021-01538-5
	Czúcz, B.; Keith, H.; Driver, A.; Jackson, B.; Nicholson, E.; Maes, J. (2021). A common typology for ecosystem characteristics and ecosystem condition variables. One Ecosystem 6: e58218. https://doi.org/10.3897/oneeco.6.e58218
	Sánchez-Clavijo, et al. (2024). Monitoreo de la biodiversidad colombiana. Instituto de Investigación de Recursos Biológicos Alexander von Humboldt. 1 edición. - Bogotá, D.C. 356 p. ISBN digital: 978-628-7721-33-3.
	UNEP-WCMC (on behalf of the Aligning Biodiversity Measures for Business initiative). (2019). Discussion Paper 1 for the Technical Workshop on Aligning Biodiversity Measures for Business: Identifying common ground between corporate biodiversity measurement approaches. https://www2.unep-wcmc.org//system/comfy/cms/files/files/000/001/608/original/1_Al

	igning_Biodiversity_Measures_for_Business_Brazil_Workshop_DiscussionPa....pdf#page=1.13
	Navarro, LM.; Fernández, N.; Guerra, C.; Guralnick, R.; Kissling, WD.; Londoño, MC. & Pereira, HM. (2017). Monitoring biodiversity change through effective global coordination. *Current opinion in environmental sustainability*, *29*, 158-169. https://doi.org/10.1016/j.cosust.2018.02.005
	Jungmeier, M. and Arpa, NY. (2022). Guidelines for biodiversity monitoring. Ankara, FAO and MAF. https://doi.org/10.4060/cb8370en
Landscape assessment	Venter, O.; Sanderson, EW.; Magrach, A.; Allan, JR.; Beher, J.; Jones, KR.; Possingham, HP.; Laurance, WF.; Wood, P.; Fekete, BM.; Levy, MA.; Watson, JE. (2016). Sixteen years of change in the global terrestrial human footprint and implications for biodiversity conservation. *Nat Commun* 7, 12558. https://doi.org/10.1038/ncomms12558
	Schipper, AM.; Hilbers, JP.; Meijer, JR.; Antão, LH.; Benítez-López, A.; de Jonge, MMJ.; Leemans, LH.; Scheper, E.; Alkemade, R.; Doelman, JC.; Mylius, S.; Stehfest, E.; van Vuuren, DP.; van Zeist, WJ.; Huijbregts, MAJ. (2020). Projecting terrestrial biodiversity intactness with GLOBIO 4. *Glob Chang Biol*. 26(2):760-771. https://doi.org/10.1111/gcb.14848
	Hill, S. L.; Harrison, M. L. K.; Maney, C.; Fajardo, J.; Harris, M.; Ash, N.; ... & Burgess, N. (2023). The ecosystem integrity index: A novel measure of terrestrial ecosystem integrity. *BioRxiv*, 2022-08. https://doi.org/10.1101/2022.08.21.504707
	Maes, J.; Bruzón, A.G.; Barredo, J.I. *et al.* (2023). Accounting for forest condition in Europe based on an international statistical standard. *Nat Commun* 14, 3723. https://doi.org/10.1038/s41467-023-39434-0

The application of methods and techniques for information gathering should consider the following:

a) Pre-planning: Identify sampling areas according to ecosystem representativeness, logistical access and project objectives;

b) Training: ensure that personnel have the necessary training for sampling, identification and handling of samples;

c) Ethics and impact minimization: avoid unnecessary damage to species and ecosystems during field activities;

d) Record: Document metadata (date, time, coordinates, weather conditions) along with evidence (e.g. photographic, bioacoustic or video);

e) Environmental Permits: guarantee the legal authorization to carry out sample collection and handling activities according to current regulations.

Annex 2. References for uncertainty analysis

Ecological models	Banos-Gonzalez, I.; Martínez-Fernández, J.; Esteve-Selma, M. -Á.; & Esteve-Guirao, P. (2018). Sensitivity Analysis in Socio-Ecological Models as a Tool in Environmental Policy for Sustainability. *Sustainability*, *10*(8), 2928. https://doi.org/10.3390/su10082928
	Agudelo, C. A. R., Bustos, S. L. H., & Moreno, C. A. P. (2020). Modeling interactions among multiple ecosystem services. A critical review. *Ecological Modelling*, *429*, 109103. https://doi.org/10.1016/j.ecolmodel.2020.109103
Confidence intervals and standard deviation	Bolker, B. M. (2008). *Ecological models and data in R* (Vol. 396). Princeton University Press.
	EPA. (2009). Guidance on the Development, Evaluation, and Application of Environmental Models. https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P1003E4R.PDF
	Conroy, M. J., & Peterson, J. T. (2013). Decision making in natural resource management: a structured, adaptive approach. John Wiley & Sons. https://doi.org/10.1002/9781118506196
Sensitivity analysis for ecological models	Wattenbach, M., Gottschalk, P., Hatterman, C., Rachimow, C., Flechsig, M., & Smith, P. (2006). A framework for assessing uncertainty in ecosystem models. *International Congress on Environmental Modeling and Software*. https://scholarsarchive.byu.edu/cgi/viewcontent.cgi?article=3613&context=iemssconference
	Saltelli, A., et al. (2008). *Global Sensitivity Analysis: The Primer*. John Wiley & Sons: Hoboken, NJ, USA.
	Jankowski, P.; Ligmann-Zielińska, A.; Zwoliński, Z. and Najwer, A. An Integrated Uncertainty and Sensitivity Analysis for Spatial Multicriteria Models (Short Paper). In 12th International Conference on Geographic Information Science (GIScience 2023). Leibniz International Proceedings in Informatics (LIPIcs), Volume 277, pp. 42:1-42:6, Schloss Dagstuhl – Leibniz-Zentrum für Informatik (2023) https://doi.org/10.4230/LIPIcs.GIScience.2023.42
Monitoring data quality assessment	Yoccoz, N. G., Nichols, J. D., & Boulinier, T. (2001). Monitoring of biological diversity in space and time. *Trends in ecology &*

	evolution, 16(8), 446-453. https://doi.org/10.1016/S0169-5347(01)02205-4
Accuracy of satellite imagery and land use maps	Foody, G. M. (2002). Status of land cover classification accuracy assessment. *Remote sensing of environment*, *80*(1), 185-201. https://doi.org/10.1016/S0034-4257(01)00295-4
	Song, X. P. (2023). The future of global land change monitoring. *International Journal of Digital Earth*, 16(1), 2279–2300. https://doi.org/10.1080/17538947.2023.2224586

Document history

Type of document. **Methodological Document**.

Version	Date	**Nature of the document**
Document for public consultation	November 21, 2022	Initial version - Document submitted for public consultation
Version 1.0	January 9, 2023	Updated version Some clarifications and minor editorial changes
Version 2.0	February 24, 2024	Updated version Quantification period Eligible activities Monitoring period
Version 3.0	August 23, 2024	Updated version Definitions Adjustments in Equations and Multiplier Factor
Version 4.0	January 27, 2025	Updated document Some definitions Mathematical model for quantification of BioCredits References for consultation