ASES ON-CHAIN PROTOCOL

METHODOLOGY FOR THE ISSUANCE OF VERIFIED BIODIVERSITY CREDITS

IV. Methodologies V2.0

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INTRODUCTION

Biodiversity is fundamental to maintaining the stability and functioning of ecosystems; each species plays a specific role in its habitat, interacting with other species and contributing to the health and resilience of the ecosystem as a whole. Loss of species can trigger ecological imbalances and have negative effects on the food chain and natural processes.

Biodiversity credits have been developed as a way to address the problem of species loss by promoting their conservation and rewarding those who take positive actions for their creation.

The carbon market has centered on degraded habitats that require funding to be protected and repaired from the consequences of climate change, and the areas that need to preserve biodiversity but exhibit signs of degradation, deforestation, or disturbance have typically gone unnoticed by the market. This approach intends to offer a brand-new source of funding for international biodiversity conservation initiatives.

Every project funded by the OCP program must include biodiversity preservation and protection as a fundamental element. As a result, this approach should be applied in programs devoted to regenerative agriculture, forest management, urban forest management, and water flow restoration.

Credits are generated through projects that encourage conservation or restoration, representing certain amounts of benefits. In the aOCP protocol, to calculate the benefit of the project and objectively estimate the number of credits, the actions taken in favor of biodiversity are evaluated based on three key variables:

- Area preserved
- Restored area
- Ecological condition of the intervened area

In the context of complexity, biodiversity refers to the amount and variety of various living forms and interactions present in an ecosystem. The greater an ecosystem's biodiversity, the greater its complexity and resilience. This is due to the fact that diverse species and interactions provide multiple paths for energy and nutrient input, which aids in maintaining ecosystem function even when certain components are absent.

I. DEFINITIONS

- **Preservation:** Conservation of ecosystems and their natural components with the objective of maintaining their integrity, biological diversity, and ecological functions in the long term through the adoption of measures and actions aimed at maintaining natural systems in a healthy and balanced state, minimizing human interference and promoting their resilience to possible disturbances.
- **Restoration:** The intentional process of restoring, rehabilitating, or reconstructing a degraded ecosystem with the objective of recovering its original or approximate structure, function, and biological diversity, through the application of techniques and practices that reverse the negative impacts caused by human activities.
- **Ecosystem:** A geographic area where plants, animals, and other organisms, as well as weather and landscape, work together to form a bubble of life. Ecosystems contain biotic, or living parts, as well as abiotic factors, or nonliving parts.
- **Biodiversity:** Refers to the range of life forms present in an ecosystem, including the diversity of species, genetic variation within species, and ecological roles and interactions. This notion is frequently employed to evaluate the complexity and health of an ecosystem. Entropy is a measure of a system's disorder and randomness. Entropy can be conceived of as the loss of biodiversity and complexity in ecosystems. When biodiversity is lost in an environment, the remaining species and interactions become more predictable and less robust. This can result in a reduction in ecosystem function and a heightened risk of ecological collapse. Margalef's concept of negative entropy of ecosystems implies that biodiversity functions as a buffer against entropy and that ecosystems with high biodiversity tend to be more resilient and stable with time. Consequently, biodiversity is essential to the long-term health and sustainability of ecosystems.
- **Protection of key species:** Keystone species in an ecosystem are those that have a disproportionately large impact on its functioning and structure, despite their low numerical abundance. These species play fundamental roles in regulating ecological processes and maintaining balance in the ecosystem.
- **Fragmentation:** Landscape fragmentation refers to the division or separation of natural habitats into smaller, isolated units, a phenomenon that causes a series of consequences at the ecosystem level and for the species that depend on them. Among the main effects are the loss of biodiversity, alteration of ecological processes, loss of ecological connectivity, and increased human pressure.
- **Fractal dimension:** A fractal dimension index is a useful tool for assessing the spatial structure of the landscape and understanding how the configuration of habitat patches can influence ecological processes and ecosystem function.
- **Spatial continuity:** The spatial continuity of natural areas guarantees the survival of plant and animal species and, therefore, the continuous exchange of genes, thus ensuring the

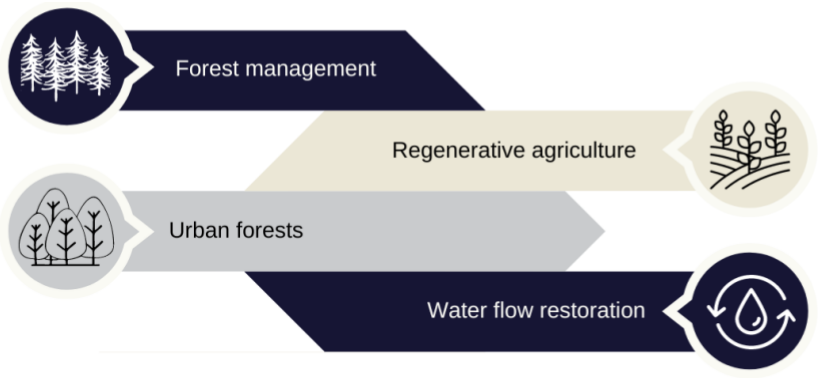
movement of species, the maintenance of ecological functions, resilience to disturbances, and the conservation of biodiversity.

- **Ecosystem vulnerability to climate change:** Climate change can influence the Net Primary Productivity (NPP) of ecosystems, which is the amount of energy that producers (such as plants) capture through photosynthesis. Variations in patterns of temperature, precipitation, and water availability can alter the quantity and quality of biomass produced, affecting the entire food chain and the availability of resources for consuming organisms.
- **Species vulnerability to climate change:** Climate change can lead to species extinctions and declines in biological diversity. Species that cannot adapt quickly to changes in temperatures or precipitation patterns may have difficulty surviving and reproducing.

II. APPLICABILITY CONDITIONS

The following conditions apply to the methodology:

a) The type of Project is:



For complementary information see Table 1.

b) The Project complies with the standards of the aOCP Program;
c) The Project was developed less than 24 months ago;
d) The Project activities exclusively focus on conservation, protection and restoration of ecosystems, with no conversion to non-native habitat / land use (i.e. conversion of forest to agriculture land);
e) The Project area has not been deforested in the last 24 months or degradation is in progress and restoration is urgently needed;
f) If a project area does not meet requirement "e," the project proponent must offer a technical reason arguing that ecological restoration is necessary because the area's biodiversity and environmental services are vulnerable;
g) The Project embeds local communities into the project activities to ensure local knowledge and cultures are applied within the project activities;
h) The biodiversity of the project area is vulnerable to degradation or perturbation if not conserved;
i) The Project shall design and implement strategies to remove or manage invasive species from within the project area;

If project activities are to be carried out, the project must also abide by the following applicable conditions in addition to the ones mentioned above:

a) Vegetation planted as part of the activities is native to the project area;
b) The creation of new habitats considers species present in the ecosystem of the project area.

III. METHODOLOGICAL CONSIDERATIONS

III.1. APPLICATION OF METHODOLOGY

The projects included in the following table should apply the methodology for assessing the impact on biodiversity since they would either directly or indirectly benefit local ecosystems and, consequently, flora and fauna:

TABLE 1. APPLICATION OF METHODOLOGY BY PROJECT

Type of project	Use of methodologies			
	Carbon in vegetation	GHG emission	Biodiversity	Water
Regenerative agriculture			✓	
Forest management			✓	
Silvopastoral				
Urban forest			✓	
Water flow restoration			✓	

III.2. METHODOLOGY PARAMETERS

The methodology's parameters and the factors that will be taken into account when using it are listed in the following table:

TABLE 2. PARAMETERS OF THE METHODOLOGY

Parameters	Index	Explanation
Biodiversity	Species richness	Indicate the number of species in a community.
	Shannon-Wiener Diversity Index (H)	Is a mathematical measure of species diversity in a given community.
	Equitability index (J)	Ratio of observed diversity to maximum expected diversity.
	Fragmentation	Division or separation of natural habitats into smaller, isolated units.

Parameters	Index	Explanation
	Fractal dimension	Index for assessing the spatial structure of the landscape
	Spatial continuity	Index for measuring the connection and transition between different features and elements of the environment
	Ecosystem vulnerability to climate change	Climate change can influence the Net Primary Productivity (NPP) of ecosystems
	Species vulnerability to climate change	Climate change can lead to species extinctions and declines in biological diversity

III.2.1. Collection of data sources

An inventory of the flora and fauna of the study region should be carried out to calculate the diversity index, which includes species richness, diversity, maximum potential diversity, and the index of equitability.

The inventory should be carried out in situ, identifying the types of plants and animals (birds, mammals, reptiles, amphibians, fish, insects, etc.) present in each ecological community, and keeping a detailed record of the data obtained (Table 3).

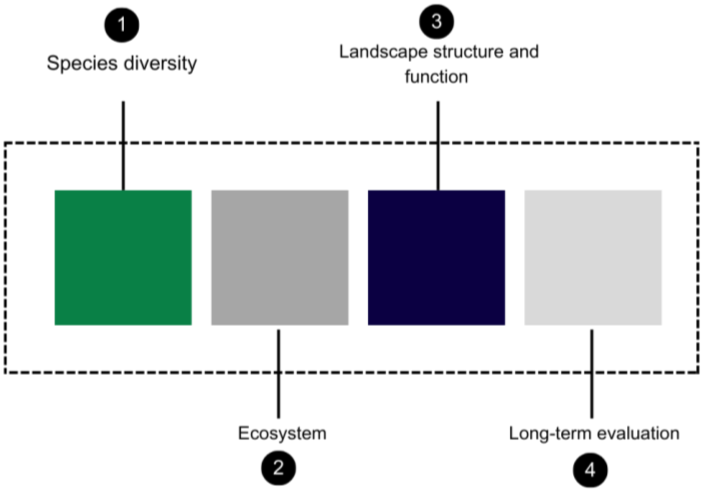
For this purpose, bioacoustic recorders can be used, and installed at strategic points in the project area, obtaining data and processing the sounds emitted by animals to identify the fauna present.

Table 3. Species Count Record Form

No.	Area of study *(Project or buffer area)*	Group *(Flora or fauna)*	Species		Number of individuals
			Scientific name	Common name	
1					
n					

IV. BASELINE SCENARIO

The proposed method for calculating the benefits of the project to biodiversity is an evaluation based on three main variables: preserved area, restored area, and ecological conditions of the intervened area. This holistic approach recognizes that biodiversity is a complex system and that its conservation requires consideration of multiple dimensions: species diversity, ecosystem, landscape structure and function, and long-term evaluation.



The method proposed is an evaluation where each of the variables is relativized. The relativization function is performed in order to assign a common scale between 0 and 1 to all the amplitude indices.

When the index has a positive relationship on the study variable with reference to the factor, the following expression is used:

$$\textbf{Relativization} = \frac{X - m}{M - m}$$

$$\textbf{VBBC}=\sum_{i=1}^{N_I} TS*(Fij)/100$$

$$\textbf{VBBC} = \frac{TS* \mathbf{(F1)*}\underline{\beta 1} + (F2)\mathbf{*}\underline{\beta 2} + (F3)\underline{*\beta 3} +..\mathbf{(Fn)*}\underline{\beta n}}{100\ m^2}$$

Where:

X: Variable value to be relativized

m: Minimum variable value

M: Maximum variable value

The preserved areas variables correspond to the baseline of the project, analyzing the surface factor (in m^2) and the diversity factor through the Shannon-Wiener index. The areas restored are those created thanks to the implementation of project activities and their measurement will also consider surface and diversity, as for preserved areas.. Finally, the ecological condition variable of the intervened area is formulated by five factors that together allow evaluation of the state of the ecosystem impacted by the project, taking into account the following:

- Protection of key species
- Fragmentation
- Fractal dimension
- Spatial continuity
- Ecosystem vulnerability to climate change
- Species vulnerability to climate change

Once each of the factors has been relativized, the following adapted formula will be applied to determine the number of Biodiversity Credits that will be awarded for the project:

$$\mathbf{VBBCs} = \frac{\text{Tsurf} * (\text{F1} + \text{F2} + \text{F3} + \text{F4} + \text{F5} + \text{F6}) + (\text{RestSurf} * \text{F7}) + (\text{PresSurf} * \text{F8})}{100}$$

Where:

Tsurf: Total surface

F_1: Protection of key species

F_2: Fragmentation

F_3: Fractal dimension

F_4: Spatial continuity

F_5: Climate change vulnerability

F_6: Vulnerability of species to climate change

RestSurf: Restored surface

F_7: Biodiversity index in the area restored

PresSurf: Preserved surface

F_8: Biodiversity index in the preserved area

This equation incorporates the relativized factors, Shannon-Wiener index values, benefits adjacent to the ecosystem and the areas of each variable to calculate the amount of biodiversity credits. Multiplying each variable by its respective area ensures that the spatial extent of each factor is taken into account. The result is divided by 100, as each credit issued will represent a 100 m^2 unit that has been preserved or restored by the project.

IV.1. VARIABLES EVALUATION

IV.1.1. PRESERVED AREA

The preserved area corresponds to the area within the property boundary of the property where the project activities were implemented, subtracting the plantation area, resulting in a conservation or preservation area, which should be reported in square meters for later inclusion in the formula.

IV.1.1.1. Flora and fauna

In order to determine the biodiversity index of the flora within the designated study area, a comprehensive survey must be conducted to count the vegetation across at least 20% of the preservation area, encompassing all strata including arboreal and shrub. It is essential to identify and mark the surveyed areas using precise coordinates, enabling their subsequent spatial representation on a map. As for fauna assessment, the analysis or monitoring of data generated by bioacoustics sensors will provide the necessary insights and results.

The result of the count (flora and fauna) will be the base information for the calculation of diversity using the Shannon-Wiener index, which is one of the most widely used indexes to quantify specific biodiversity, also known as Shannon-Weaver (Shannon and Weaver, 1949), derived from the theory of information as a measure of entropy. The index reflects the heterogeneity of a community based on two factors: the number of species present and their relative abundance. The maximum potential diversity (Hmax= lnS) depends on the number of species present in the community, the more species there are, the higher the maximum potential diversity; it is reached when all species are equally represented. An index of homogeneity, also called equitability, associated with this measure of diversity can be calculated as the ratio H/Hmax, which will be equal to 1 if all the species that compose the community have the same number of individuals.

The index is calculated through the following equation:

$$\boldsymbol{H} = -\sum_{i=1}^{ps*} pi \ln(pi)$$

Where:

H: Shannon-Wiener diversity index (nat)

Pi (p_1,p_2, p_3… p_s*): It is the relative abundance of species i in the collection

If only part of the area is sampled, biodiversity is expressed according to the following relationship.

$$\boldsymbol{H} = \sum_{i=1}^{s} [(\frac{ni}{n} \ln \frac{ni}{n})]$$

Where:

n$\boldsymbol{i}$: Abundance of species i

n: Abundance of all species/categories of the sample

The diversity is influenced by the distribution of the species' relative abundance in the community. The **Equitability index** (J) is calculated as follows:

$$J = \frac{H}{Hmax}$$

$$J = \frac{D}{Dmax}$$

Where:

H: Shannon-Wiener diversity index (nat)

Hmax: Maximum diversity that can be expressed through the sample, which is calculated as:

$$Hmax = \ln S$$

Where, S: species richness, i.e., number of species in the sample **(nat)**.

The results of the specific richness, Shannon-Weaver diversity index, maximum diversity, and equitability index of the tree and shrub community and fauna in the project preservation area will be presented in a table as the following, one for flora and one for fauna.

Parameters of flora diversity index	Preservation area
Species richness	
Diversity (nats)	
Maximum potential diversity (Hmax)	
Equitability index (J)	

When the value of the diversity index is 0, there is only one species, i.e., there is no diversity; and the index increases as the number of species or classes increases or if the proportional distribution of the occupied area among ecosystem types or objects, species, etc., is more equitable.

The diversity index obtained for the preservation zone will be interpreted according to the categories presented in Table 4.

TABLE 4. QUALITATIVE CATEGORIES OF INTERPRETATION OF THE SHANNON INDEX

Diversity	Shannon index (nats)
Very low	<1.02
Low	1.03 – 1.53

Medium	1.58 – 2.11
High	2.12 – 2.65
Very high	>2.65

Bibliographical source: Qualitative interpretation of the index based on the interpretations expressed by Margalef (1975;1993).

IV.1.2. RESTORED AREA

The restored area corresponds to the surface (in square meters) on which the project activities have been carried out. To evaluate this parameter, the benefits of reforestation will be calculated using the Shannon diversity index presented above using the number of individuals that have been planted.

The results of the specific richness, Shannon-Weaver diversity index, maximum diversity, and evenness of the tree and shrub community in the project restoration area will be presented in a table.

Parameters of flora diversity index	Restored area
Species richness	
Diversity (nats)	
Maximum potential diversity (Hmax)	
Equitability index (J)	

The diversity index obtained for the preservation zone will be interpreted according to the categories presented in Table 4.

IV.1.3. ECOLOGICAL CONDITION OF THE INTERVENED ZONE

IV.1.3.1. Protection of key species

Keystone species are those that play a fundamental role and whose conservation has a positive impact on the preservation of other organisms and the ecosystem itself.

From the flora and fauna list generated by direct counting and ultrasonic recorders, species that are globally protected by the IUCN Red List and/or by the lists and protection regulations of each country will be identified and considered as key species. Subsequently, the Shannon-Weaver diversity index will be calculated, for the identified key species, by applying the methodology described above.

The results of the specific richness, Shannon-Weaver diversity index, maximum diversity and evenness of the tree and shrub community as well as the fauna of the project restoration area will be presented in a table.

Parameters of flora diversity index	Preservation area
Species richness	
Diversity (nats)	
Maximum potential diversity (Hmax)	
Equitability index (J)	

The diversity index obtained for the preservation zone will be interpreted according to the categories presented in Table 4.

IV.1.3.2. Fragmentation

Due to the complexity of the landscape, and the need to include diverse physical, biological, cultural, and social factors, the analysis will be carried out at two different scales depending on the location of the project:

- **Microbasin:** When the project is located in a natural or forested area, the fragmentation analysis shall be evaluated at the microbasin scale.
- **Area of influence:** When the project is located in an urban or human-influenced area, the fragmentation analysis shall be conducted at the scale of the area of influence of 1 km around the project.

The vegetation area within the microbasin or the area of influence, as applicable, shall be determined by digitizing it through a satellite image with a supervised or unsupervised classification method. The objective will be to have the vegetation patches present at the scale of analysis.

The total fragmentation of the landscape is estimated through the ratio between the forest area and the total area, represented by the following formula:

Fragmentation = Area of forest (ha) / Total area (ha)

The fragmentation index gives values ranging from 0 to 1, where values less than 0.5 indicate an insularized degree of fragmentation, meaning that the landscape has a high level of fragmentation resembling the way islands are scattered in an ocean. While value 1 represents a landscape with no fragmentation (Table 5).

TABLE 5. FRAGMENTATION RANGE

Fragmentation range	Level
<0.5	Insularized
0.5 – 0.7	Highly fragmented
0.7 – 0.9	Moderate fragmentation
1	Without fragmentation

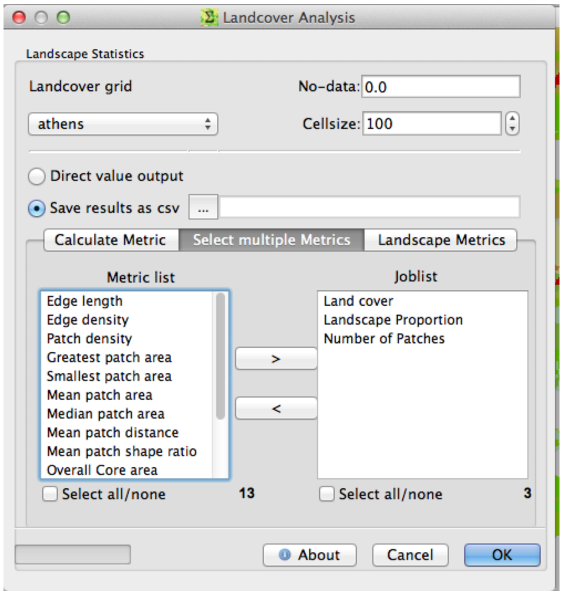
Bibliographical source: Díaz, A (2003)

- **Insularized:** Refers to a condition in which a geographic area resembles or behaves like an island, despite not being surrounded by water. An insularized landscape can occur when a natural region or specific habitat is surrounded by a matrix of agricultural land, urbanized areas, or other intensive land uses. This fragmentation of the landscape can be the result of deforestation, uncontrolled urbanization, infrastructure construction, or agricultural expansion.
- **Fragmented:** Landscape that has been divided into multiple smaller fragments due to human or natural influence. This fragmentation of the landscape occurs when natural habitats and open areas are divided into smaller, isolated fragments due to activities such as urbanization, infrastructure construction, deforestation, intensive agriculture, etc. Fragmentation causes habitat loss, isolation of populations, alteration of ecological processes, increased vulnerability to disturbances, and the reduction or loss of ecosystem services.
- **Without fragmentation:** An area in which natural habitats and open areas are in a continuous state and have not been divided into smaller fragments. In an unfragmented landscape, ecosystems and natural habitats are maintained in their original form, without significant disruption caused by human activities or natural phenomena.

IV.1.3.3. Fractal dimension

This index measures the complexity of shapes, its value lies between 1 and 2, where values closer to 1 correspond to the most regular perimeters, while values closer to 2 correspond to very complex shapes.

The fractal dimension index should be calculated with the Landscape Ecology Statistics (LecoS) plugin of QGIS, which will use as input the forest area at the microbasin scale or area of influence (as applicable) in raster format that was delimited in the previous section.



The result obtained will be classified according to the categories presented in Table 6.

TABLE 6. FRACTAL DIMENSION RANGE

Fractal dimension range	Level
< 1.25	Round
1.26 - 1.50	Oval-round
1.51 - 1.75	Oval oblong
1.76 - 1.99	Rectangular
2	Amorphous or irregular

Bibliographical source: Patton D.R. (1975)

IV.1.3.4. SPATIAL CONTINUITY

For the evaluation of spatial continuity as an indicator of fragmentation, the Volgelmann Index (FCI) applied to the scale of the micro-watershed or area of influence of the project, as applicable, will be used. The formula is composed as follows:

$$FCl = \ln(\Sigma A / \Sigma P)$$

Where:

FCI: Volgelmann Index of spatial continuity

Σ A: Total area of forest patches in the landscape (m^2)

Σ P: Total perimeter of forest patches in landscape (m)

Values less than zero indicate a landscape with spatial continuity, while higher values represent greater discontinuity and fragmentation of patches.

TABLE 7. SPATIAL CONTINUITY INDEX

Index value	Spatial continuity
< 0	Continuous
0.10 - 5	Discontinuous
> 5	Highly discontinuous

IV.1.3.5. ECOSYSTEM VULNERABILITY TO CLIMATE CHANGE

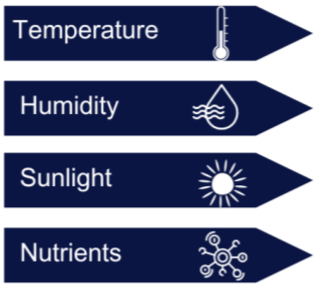
Vulnerability to climate change is a highly relevant factor to consider, and its evaluation will be carried out using biomass data as a fundamental element to sustain species diversity in ecosystems, as its reduction could lead to a decrease in habitats and resources available for species, which would have a direct impact on biodiversity.

IV.1.3.5.1. Net Primary Productivity

Net Primary Productivity is the result of the production of organic matter through the photosynthesis process. However, primary productivity requires more than photosynthesis, particularly the uptake of inorganic nutrients and the incorporation of various organic compounds into protoplasm, essential for all photosynthetic organisms.

Among all ecosystem processes, NPP is the most measured because it reflects the carbon accumulation in ecosystems. The NPP is expressed as the increase in biomass per area unit per time unit.

The NPP depends on the following factors:



Thus, the net primary productivity is equal to the carbon absorbed by the vegetation through photosynthesis (called Gross Primary Production or GPP) minus the carbon lost through respiration.

The NPP is limited by temperature and precipitation, it is assumed that it increases with both temperature and precipitation. However, in both cases, the saturation value of 3000 gDM/m^2/year (DM: dry matter) can not be exceeded.

The NPP of the project area was calculated using the Miami methodology, the process takes into account the following equations:

$$\mathbf{NPP} = \mathbf{min}\ (\mathbf{NPP_T}, \mathbf{NPP_P})$$

Where:

$$NPP_T = 3000(1 + exp(1.315 - 0.119 * T))^{-1}$$

$$NPP_P = 3000(1 - \exp(-0.000664 * P))$$

Where:

T: average annual temperature

P: accumulated annual precipitation

The climate sensitivity of the NPP can be defined as the derivative of the NPP concerning changes in climate variables, λP = ∂NPP/∂P in g(DM)/m^2/yr/(mm/yr) = gDM/ m^2/mm and λT = ∂NPP/∂T in gDM/m^2/year/°C respectively.

Direct differentiation leads to

$$\lambda\mathrm{T} = \frac{3000 * 0.199 \exp(1.315 - 0.119 * T)}{(1 + \exp(1.315 - 0.119 * T))^2} \quad \text{, if } NPP_T < NPP_P$$

o

$\lambda P = 3000 * 0.000664 \exp(-0.000664 * P)$, if $NPP_P < NPP_T$

Biomass = Total area (m^2)* NPP (kg)

To calculate the vulnerability of the ecosystem to climate change, the net primary productivity should be calculated in the current and 2050 climate change scenarios using the IPCC modeling inputs (RCP 45).

The result will be the difference in biomass obtained for the project area in the current and future (2050) scenarios.

IV.1.3.6. SPECIES VULNERABILITY TO CLIMATE CHANGE

The vulnerability to climate change of the reforested species should be evaluated based on the current and future potential distribution models (2050 RCP 4.5) of each planted species, using the Climpact Data Science tool (https://www.cdstoolbox.shop) with the objective of determining the percentage of conditions that the project area currently presents with respect to ecological (temperature, precipitation, etc.), physical (altitude) and biological (vegetation) needs, compared to the percentage of conditions that they will find under the climate change scenario in the year 2050.

Climpact is an integrated model that allows the evaluation of optimal zones for the distribution and presence of species in a current and future time horizon. The Climpact tool takes as its main input physical, environmental and biological parameters related to species and their distribution, making it possible to identify spatially over a given territory, the potential optimal zones in which a species or a community of species could grow and survive.

Thus, Climpact Data Toolbox is based on the theory of ecological niches, which are considered as "the position of a species within an ecosystem, describing both the range of conditions necessary for the species' persistence and its ecological role in the ecosystem" (Polechonvá and Storch, 2019). Habitat is considered the physical space where a species finds food, mating sites, and shelter (Mitchell and Power, 2002). A source habitat occurs when environmental conditions are sufficient to satisfy the needs of organisms, which paves the way for the concept of ecological field (Farina and Belgrano, 2004).

Climatic variables acquire significant relevance since they greatly influence the survival and adaptation of species, especially in areas where climatic gradients are significant. This also provides a description of the climatic envelope of each species and can also be considered a limiting factor (Woodward, 1987). The following diagram schematizes the first step, calibration, of the Climpact Data Toolbox process.

Calibration between species and environmental variables

Inputs

Climatic variables

- Mean annual temperature
- Mean diurnal range
- Isothermability
- Temperature seasonality
- Maximum temperature of the warmest month
- Minimum temperature of the coldest month
- Annual temperature range
- Mean temperature of the wettest four-month period
- Average temperature of the driest four-month period
- Average temperature of the hottest four-month period
- Average temperature of the coldest four-month period
- Annual precipitation
- Precipitation of the wettest month
- Precipitation of the driest month
- Precipitation seasonality
- Precipitation of the wettest four-month period
- Precipitation of the driest quarter
- Precipitation of the warmest quarter

Biological variables

- Land use and vegetation

Natural environment variables

- Soil science
- Topography
- Geology
- Slope

Structural variables

- Carrying capacity from Net Primary Productivity index PPN

Calibration of species and species communities with climatic normals, land cover and physical environment model.

Outputs

Climatic variables

- Minimum and maximum distribution ranges

Biological variables

Plant strata and land use where observations have been recorded.

Natural environment variables

- Soil and rock types where observations have been recorded.
- Minimum and maximum slope ranges

Study area weighted from 1 to 23, which translates as follows:

23 = 100% of optimal conditions

22 = 95.6% of optimal conditions

21 = 91.3% of optimal conditions

20 = 86.9% of optimal conditions

……

3 = 13% of optimal conditions

2 = 8.6% of optimal conditions

1 = 4.3% of optimal conditions

The Climpact approach uses the two-time horizons (current and future) in order to compare the results and identify possible trends (increase, decrease, or stability) in the spatial distribution of the optimal zones for the species. In this way, the percentages of each species will be evaluated in the current and future scenarios, assessing their behavior:

- If the project zone increased the percentage of conditions necessary for the adaptation of the species.
- If the project zone decreased the percentage of conditions necessary for the adaptation of the species.

IV.2. CLASSIFICATION OF RELATIVIZED VARIABLES

Once the results of each variable analyzed have been obtained, they will be evaluated according to the classifications and relativized factors presented in the following table.

Factor		Value obtained for the project	Clasification	Value index	Relativized factor
F1	Biodiversity index of key protected species		Very low	< 1.02	0.01
			Low	1.03 - 1.53	0.14
			Medium	1.54 - 2.11	0.32
			High	2.12 - 2.65	0.67
			Very high	> 2.65	1.00
F2	Fragmentation		Insularized	<0.5	0.20
			Highly fragmented	0.5 – 0.7	0.33
			Moderate fragmentation	0.7 – 0.9	0.66
			Without fragmentation	1	1.00
F3	Fractal dimension		Round	< 1.25	1
			Oval-round	1.26 - 1.50	0.68
			Oval oblong	1.51 - 1.75	0.34
			Rectangular	1.76 - 1.99	0.26
			Amorphous or irregular	>2	0.16
F4	Spatial continuity		Continuous	< 0	1.00
			Discontinuous	0.10 - 5	0.02
			Highly discontinuous	> 5	0.01
F5	Ecosystem vulnerability to climate change		Very low	0 - 1	1.00
			Low	1 - 3	0.67
			Medium	4 - 6	0.33
			High	7 - 10	0.16
			Very high	> 10	0.11
F6	Species vulnerability to climate change		Species with very high resilience	<10	1.00
			Highly resilient species	11 - 20	0.72

Factor		Value obtained for the project	Clasification	Value index	Relativized factor
			Species with medium resilience	21 - 40	0.44
			Species with low resilience	41 - 60	0.15
			Species with very low resilience	61 - 80	0.07
			Non-resilient species	80 - 100	0.01
F7	Biodiversity index in the area restored		Very low	< 1.02	0.01
			Low	1.03 - 1.53	0.14
			Medium	1.54 - 2.11	0.32
			High	2.12 - 2.65	0.67
			Very high	> 2.65	1.00
F8	Biodiversity index in the preserved area		Very low	< 1.02	0.01
			Low	1.03 - 1.53	0.14
			Medium	1.54 - 2.11	0.32
			High	2.12 - 2.65	0.67
			Very high	> 2.65	1.00

Once the indexes for each factor and their relativization have been obtained, the formula proposed for the calculation of biodiversity credits will be applied.

$$\mathbf{VBBCs} = \frac{\mathrm{Tsurf} * (\mathrm{F1} + \mathrm{F2} + \mathrm{F3} + \mathrm{F4} + \mathrm{F5} + \mathrm{F6}) + (\mathrm{RestSurf} * \mathrm{F7}) + (\mathrm{PresSurf} * \mathrm{F8})}{100}$$

V. MONITORING

Biodiversity monitoring for each project will be carried out during the **10 years** in which the total credits will be issued; the periods of each monitoring will be determined in the specific *Monitoring Plan* for each project. Considering the results of the baseline as the reference parameter, which should not show a decrease throughout the project. Therefore, the verifications should evaluate each parameter analyzed in the baseline to monitor whether the project is effectively complying.

TABLE 8. PARAMETER CONSIDERED IN THE VERIFICATION

Parameter: H (Diversity index)	
Description	The biodiversity index should show an increase due to Project activities.
Equation	$H = -\sum_{i=1}^{S} Pi \, log_2 \, Pi$
Source of data	Information captured during the inventories in the preservation and restoration area
Purpose of data	To know the biodiversity index before and after the implementation of the project.
Parameter: Fragmentation	
Description	The fragmentation index should show a decrease due to Project activities
Equation	Area of forest (ha) / Total area (ha)
Source of data	Information generated through the digitization of vegetation areas using satellite imagery.
Purpose of data	To know the fragmentation index before and after the implementation of the project.
Parameter: Fractal dimension	
Description	The fractal dimension index should show a decrease with a trend toward a round level
Equation	Landscape Ecology Statistics (LecoS) plugin of QGIS
Source of data	Information generated through the digitization of vegetation areas using satellite imagery.

Purpose of data	To know the fractal dimension index before and after the implementation of the project.
Parameter: Spatial continuity	
Description	The spatial continuity index should show a decrease with a tendency to -0
Equation	**FCI =** ln (Σ A /Σ P)
Source of data	Information generated through the digitization of vegetation areas using satellite imagery.
Purpose of data	To know the spatial continuity index before and after the implementation of the project.

VI.2. TEMPORALITY

TABLE 9. SCHEDULE OF ACTIVITIES

Activity	Temporality	
	Prior to the start of the Project	First year of the Project's life
Inventory of fauna (birds, mammals, reptiles and amphibians)	✓	✓
Inventory of flora	✓	✓
Calculation of Biodiversity Indexes for fauna	✓	✓
Calculation of Biodiversity Indexes for flora	✓	✓

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DOCUMENT HISTORY		
Version	**Date**	**Comments**
V2.0	25/06/2023	Second version released for review by the aOCP Steering Committee under the aOCP Version 2.