ASES ON-CHAIN PROTOCOL

BASELINE FIELD REPORT

Ecological restoration in Alía, Cáceres, Spain

LT-007-SPA-072023 CÁCERES, SPAIN
Stichting Life Terra
Type B Project

October 2023

www.nat5.bio/index.php/projects

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EXECUTIVE SUMMARY

The baseline report of the projects is a necessary activity for their certification since it will allow for establishing the initial parameter of the area through the NDVI index, which is an indicator used to evaluate the vegetation and the health of the plants, thus allowing us to establish the scenario prior to the planting activities. It will also be the comparative basis for the quarterly monitoring of the project, which will be prepared following the ***"aOCP Methodology for satellite monitoring of projects V2.0".*** In addition, the Baseline report allows for establishing the number of credits to which each project may aspire according to the characteristics of the project that has been developed and based on the aOCP calculation Methodologies.

The ecological restoration of a forested area in Alía, Cáceres (Spain) entailed planting a total of 60,717 trees, representing nineteen (19) distinct species mainly native to the region and well-suited for adverse environmental conditions. The primary objective of this initiative was to enhance biodiversity, improve soil quality, and provide resources to landowners. The project area, situated within the Alía municipality, covered 383,421.50 square meters.

The dense planting technique was employed, providing numerous benefits such as increased yield and efficient resource utilization. The average planting density within the plot was one tree per 5.4 square meters, equivalent to an average of 1,861 trees per hectare in the plot.

The ecological restoration of a forested area in Alía, Cáceres will allow the removal of **15,710 tons of carbon** during its useful life (40 years), calculated using the *"aOCP Methodology for carbon removal and storage in vegetation V2.0"*, which will be monitored quarterly as defined in the Project Monitoring Plan (Annex 1), following the *"aOCP Methodology for carbon removal monitoring V1.0"*. In addition, **9,520 Verified Biodiversity Based Credits (VBBCs)** will be issued for the project's biodiversity benefits, which were measured following the *"aOCP Methodology for biodiversity assessment V2.0".*

The successful reforestation endeavor in Alía demonstrates the positive impact of employing dense planting techniques and strategically selecting native species to reclaim and revitalize degraded landscapes, providing ecological, economic, and social benefits for the region and its communities.

I. PROJECT DESIGN

This section is based on the information compiled in the PSF Format - Project Submission Form prepared by the project developer.

I.1. PROJECT LOCATION

The project is located in the Alía municipality, in the province of Cáceres (Spain). The afforested plot lies close to adjoining Coniferous Forest areas and Natural grasslands. A project location map is illustrated in Image 1. Table 1 shows the coordinates of the reforested Plots.

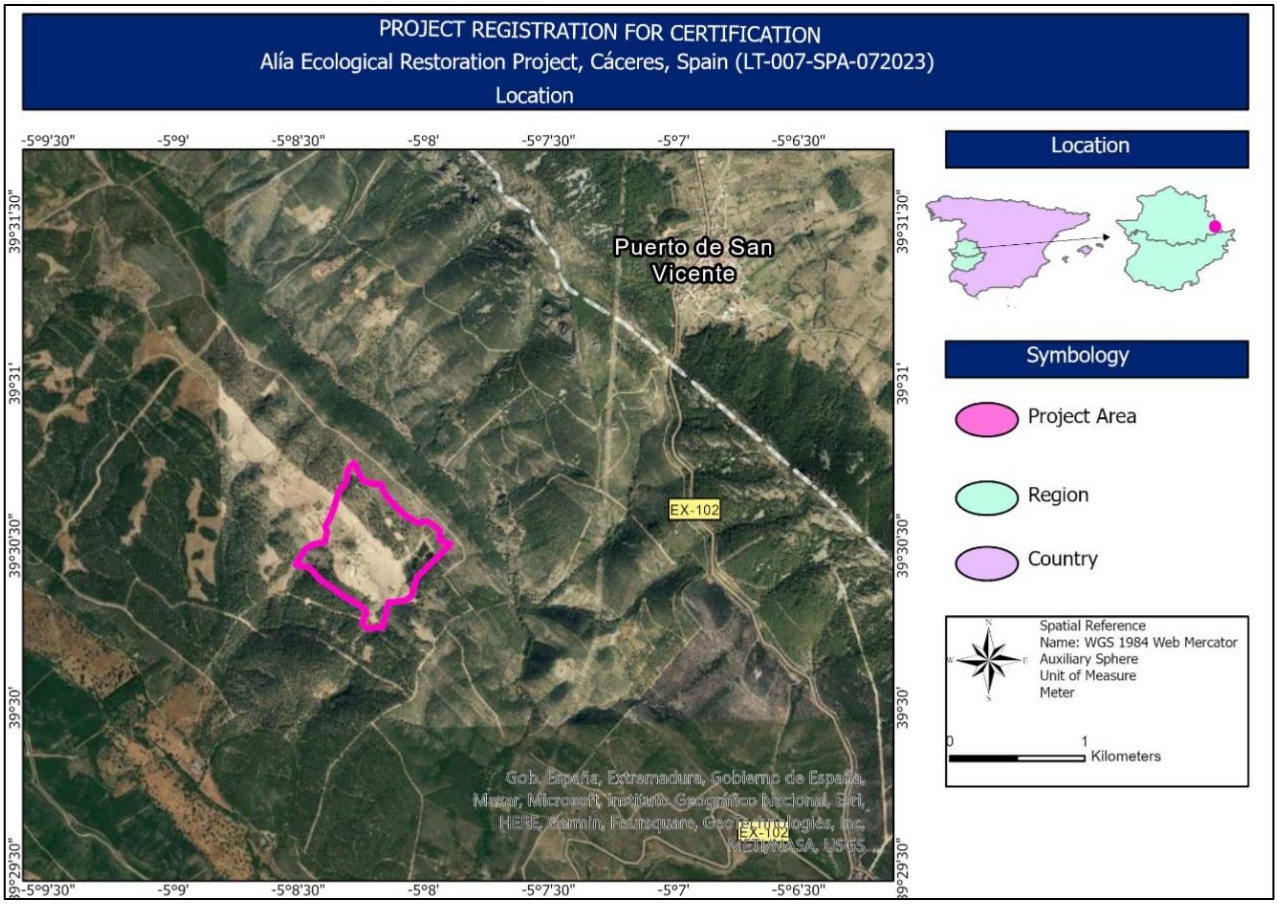


IMAGE 1. PROJECT LOCATION

TABLE 1. LOCATION OF PROJECT PLOT

Plot	Coordinates	
	Latitude	Longitude
1	39.5076876°N	5.1373499°W

I.2. Administrative specifications

This section introduces the project developer and provides a clear understanding of the roles and responsibilities assigned to each party involved. It also addresses the status of land ownership, ensuring transparency and certainty regarding the agreements made with the landowners.

I.2.1. Project developer

Key project	LT-007-SPA-072023 CÁCERES, SPAIN
Title of the project activity	Ecological restoration in Alía, Cáceres (Spain).
Company	Life Terra
Person responsible	Sven Kallen
Fiscal address	1043 CR Ámsterdam – The Netherlands
Telephone	+31.20 2620240
Mail of the person authorized to receive notifications	sven@lifeterra.eu

I.2.2. Type of project

Type	☒ Forest management ☐ Regenerative agriculture ☐ Silvopastoral management ☐ Individual tree-based climate action / urban forest ☐ Water flow restoration ☐ Biochar

I.2.3. VNPCs the project is applying to

Type of VNPCs the project is applying for	☒ Carbon Removals (VCR) ☒ Biodiversity Based Credit (VBBC) ☐ Water Credits (VWC) ☐ Soil Credits (VSC) ☐ Climate action bond

II. PROJECT AREA BASELINE

According to the Corine Land Cover mapping, the project area falls within Forest and semi natural areas with Scrub and/or herbaceous vegetation, Sclerophyllous vegetation associations, as well as Transitional woodland-shrub and Natural grasslands in the Alía municipality, Spain. Adjoining land covers include Coniferous Forest areas, Natural grasslands and herbaceous vegetation associations extending few kilometers from the site. An evaluation of the ESA-worldcover-v200 for 2021, focusing on land use and land cover, revealed that the project site was situated within a predominantly Grassland area with Tree cover areas, Shrublands, and areas with sparse vegetation. To further ascertain the project's potential contributions to biodiversity, a survey was conducted to count and identify the plant species present in the vicinity of the project area. This will be further elaborated in the biodiversity section of the baseline report.

II.1. ECOLOGICAL ADDITIONALITY

II.1.2. SPECTRAL RESPONSE

When solar radiation interacts with an object, one of three situations can occur, either individually or in combination:

- **Reflection:** The radiation can bounce off the object partially or entirely, resulting in reflection.
- **Absorption:** The object can absorb the radiation, taking in its energy.
- **Transmission:** Radiation can pass through one object and reach another, known as transmission.

The extent to which radiation is reflected, absorbed, or transmitted depends on the specific physicochemical characteristics of the objects involved. However, for object identification purposes, our primary interest lies in the reflected light or radiation at different wavelengths. For instance, vegetation exhibits low reflectance in the visible range, but the presence of chlorophyll in plants increases reflectance in the green channel. On the other hand, plants demonstrate the highest reflectance in the near-infrared region of the electromagnetic spectrum.

II.1.2.1. Index

Vegetation indices (VI) are extensively employed for monitoring and detecting changes in vegetation and land cover. These indices are created by considering the contrasting absorption, transmittance, and reflectance of energy by vegetation across the red and near-infrared portions of the electromagnetic spectrum. Numerous studies have demonstrated that the Normalized Difference Vegetation Index (NDVI) is particularly resilient against the influence of topographic factors. NDVI is commonly utilized as a broad indicator of photosynthetic activity in plants and the corresponding aboveground primary production.

The calculation of NDVI was performed using Sentinel-2 satellite images in the Google Earth Engine platform. Images with the less than 20% cloud cover was selected for each month. The assessment focused on the average monthly NDVI time series spanning from January 1, 2021, to August 13, 2023. The findings are presented in Image 3, which covers both pre- and post-project implementation periods. To delineate the pre- and post-project implementation periods, it is important to note that the reforestation activities took place between January 2023 and May 2023. Consequently, all months prior to these dates are considered as the pre-project implementation period, while months after are regarded as the post-project implementation period for the purpose of this analysis. Analyzing the NDVI values within the plot reveals a spectrum ranging from 0.05 to 0.39 prior to the project's initiation. The absence of any prior deforestation or degradation in this plot clarifies the absence of significant declines in NDVI during this timeframe. However, the sporadic fluctuations can be attributed to seasonal changes or the impact of cloud cover on spectral signals. The average NDVI in this area is reflective of the plot's sparse vegetation, hence the values within 0.05 to 0.39 range.

Given the known information that a healthy, dense vegetation canopy typically exhibits NDVI values above 0.5, while sparse vegetation generally falls within the range of 0.2 to 0.5. The current assessment indicates that the reforestation project has potential in fostering an ascending trend in the plot's NDVI as it transitions to a dense forested area. With the project in place, it is anticipated that the NDVI will continue to rise further, eventually reaching a level indicative of a healthy and thriving vegetation cover.

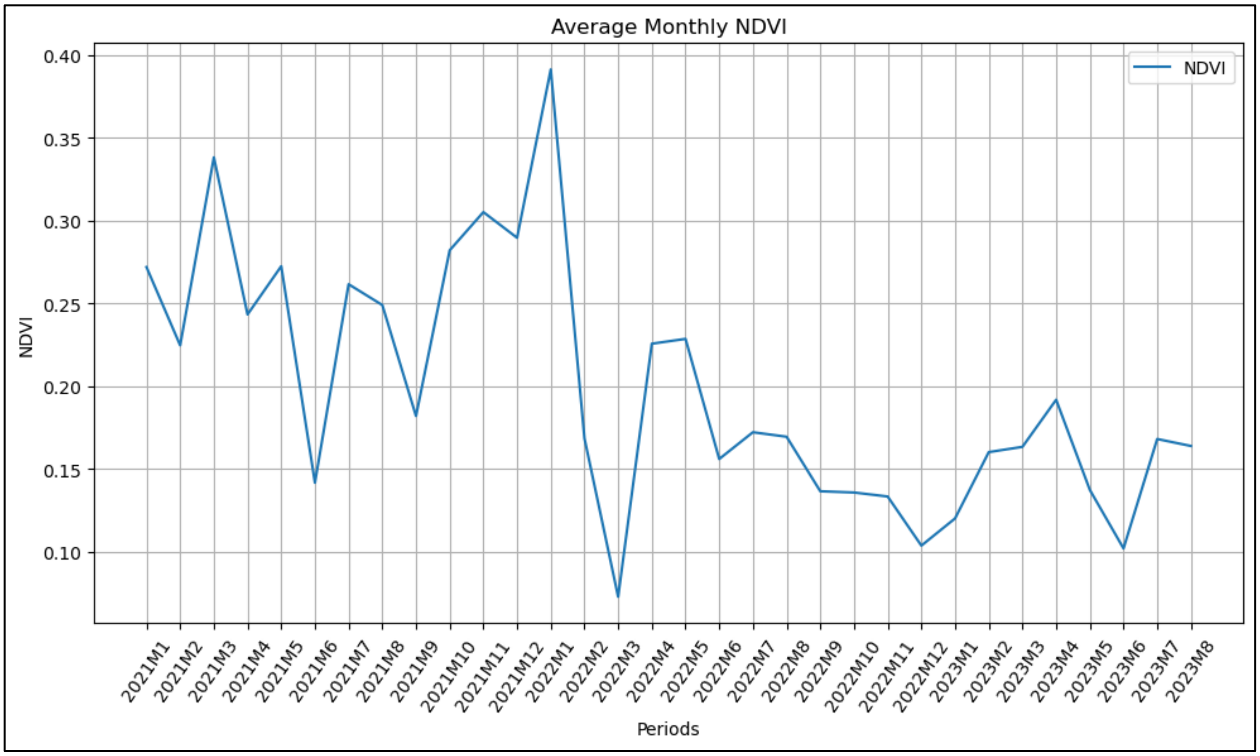


IMAGE 2. NDVI TIME-SERIES IN THE AREA OF INTEREST

II.1.3. IMPACT ON THE LANDSCAPE

Prior to reforestation of the area, it experienced decreased biodiversity, and reduced ecosystem services. The ecological restoration effort however contributes to the conservation of plant and animal species by providing new habitats and restoring corridors for wildlife movement as healthy forests are crucial for the survival of many species. In addition, the reforestation contributes to the reestablishment of natural hydrological cycles, by slowing down runoff, enhancing water infiltration, and reducing soil erosion. This helps regulate water flow, improve water quality, and mitigate the impacts of flooding. An added advantage is the reforested landscapes offering aesthetic beauty and recreational opportunities. They can provide green spaces for leisure activities, such as hiking, wildlife observation, and eco-tourism, enhancing the well-being of local communities and visitors.

Furthermore, there are intentions to construct an eco-friendly hostel within the plot, aligning with sustainability principles. This establishment will serve as a hub for recreation and environmental education, where visitors will be immersed in the understanding of the plantation's advantages and have the opportunity to witness indigenous animal species in their natural habitat.

IMAGE 3. SATELLITE AERIAL VIEW OF PRE-AFFORESTATION PROJECT (2021)

III. TECHNICAL SPECIFICATIONS

III.1. CARBON REMOVAL

This section analyzes the carbon sequestration expected by the project from the reforestation.

III.1.1. REFORESTED AREA

The project encompasses a plot with a total area measuring 38,3421.50 m^2 situated in Alía municipality, in the Cáceres province (Spain). The demarcated plot is shown in Image 5.

III.1.2. SPECIES

The reforestation project successfully planted a total of 60,717 trees, encompassing nineteen different species. The number of individuals of each species is shown in Table 2. The selection of species was based on a preliminary assessment of the region, considering available bibliographic information, as well as the prevailing climatic, vegetational, and meteorological conditions. All species chosen are indigenous to the area and well-suited to the local climate and environmental conditions.

Out of the total number of trees planted (60,717), the percentage by species is presented in Table 2.

TABLE 2. NUMBER OF TREES BY SPECIES

Species	Number of trees	Percentage (%)
Acer monspessulanum	600	0.99
Acer pseudoplatanus	135	0.22
Castanea sativa	40	0.07
Cupressus arizonica	14040	23.12
Cupressus sempervirens	15266	25.14
Ficus carica	135	0.22
Genista cinerea	2640	4.35
Genista scorpius	1026	1.69
Genista umbellata	3360	5.53
Lavandula angustifolia	7020	11.56
Lavandula stoechas	2025	3.34
Morus nigra	225	0.37
Populus nigra	540	0.89
Prunus avium	12000	19.76
Prunus dulcis	90	0.15
Prunus mahaleb	270	0.44
Quercus pyrenaica	675	1.11
Quercus rubra	540	0.89
Taxus baccata	90	0.15

Species	Number of trees	Percentage (%)
Total	60,717	100%

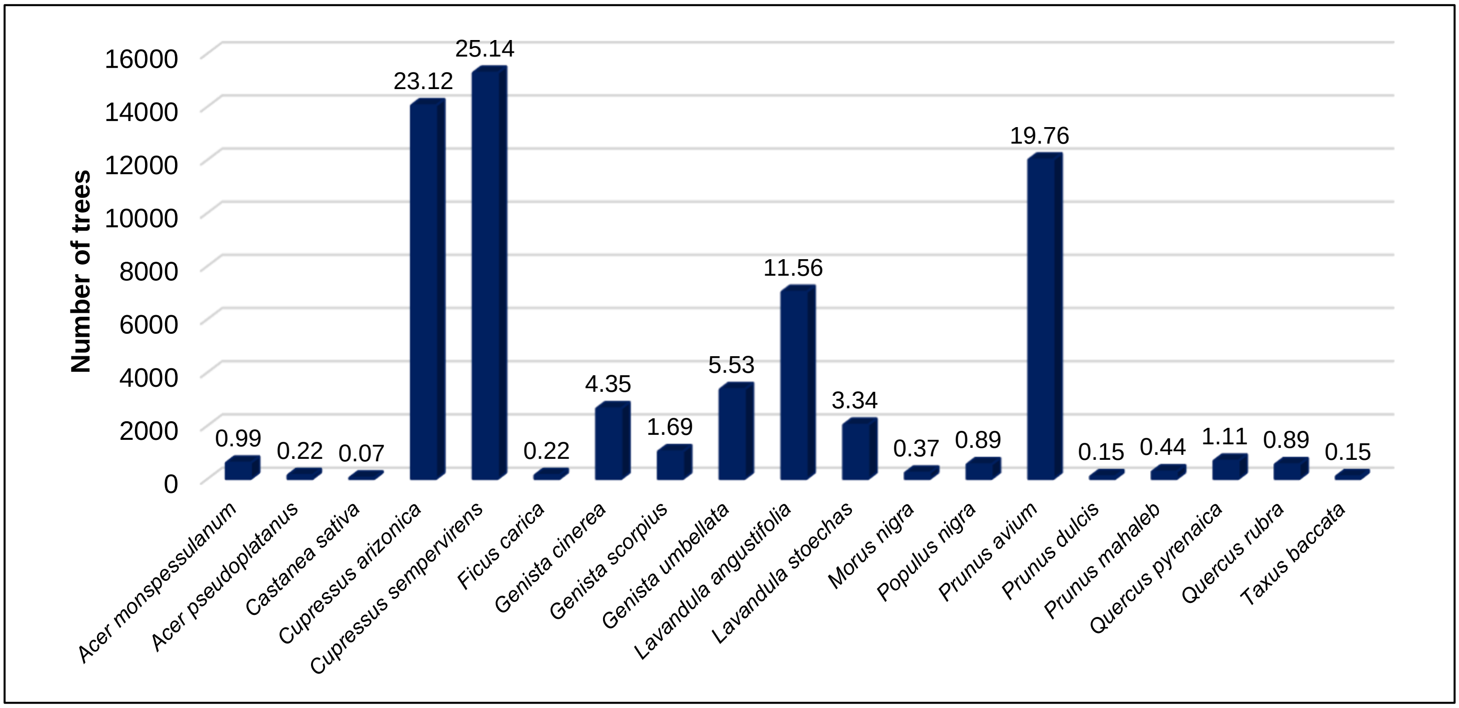


IMAGE 4. NUMBER OF TREES BY SPECIES

The assessment revealed an average planting density of one tree per 5.4 square meters, equivalent to an average of 1,861 trees per hectare in the plot. This high-density approach offers several ecological, environmental, and economic advantages. The increased tree density, combined with the implementation of various tree species, will foster biodiversity and enhance ecological resilience within the restored ecosystem. Moreover, the high density will expedite canopy closure, creating a continuous cover as the tree canopies interlock. This canopy closure plays a crucial role in weed suppression, creating improved microclimates, and moisture retention, and reducing soil erosion. However, it's important to note that high planting densities can also lead to competition for resources among trees, which may result in stunted growth, reduced health, and increased mortality of some trees. In addition, the close proximity between trees can facilitate the rapid spread of diseases and pests. Controlling and managing these issues becomes more complex in densely planted areas.

As a result of this high-density planting strategy, the reforestation project is well-positioned to maximize carbon sequestration potential, promote wildlife habitat, and provide essential ecosystem services. The management of this densely planted plot will be critical to ensure the continued success and long-term sustainability of the reforestation efforts. Image 5 shows the mapped planting density of the geolocalized trees within the plots with the location of each tree represented by dot symbols.

The technical data sheets providing detailed information about the species utilized for the reforestation project are included below, in Table 3. These sheets offer comprehensive insights into the characteristics, growth patterns, environmental requirements, and other relevant details of the selected plant species. These data sheets serve as valuable references for understanding the specific attributes and suitability of each species for reforestation efforts.

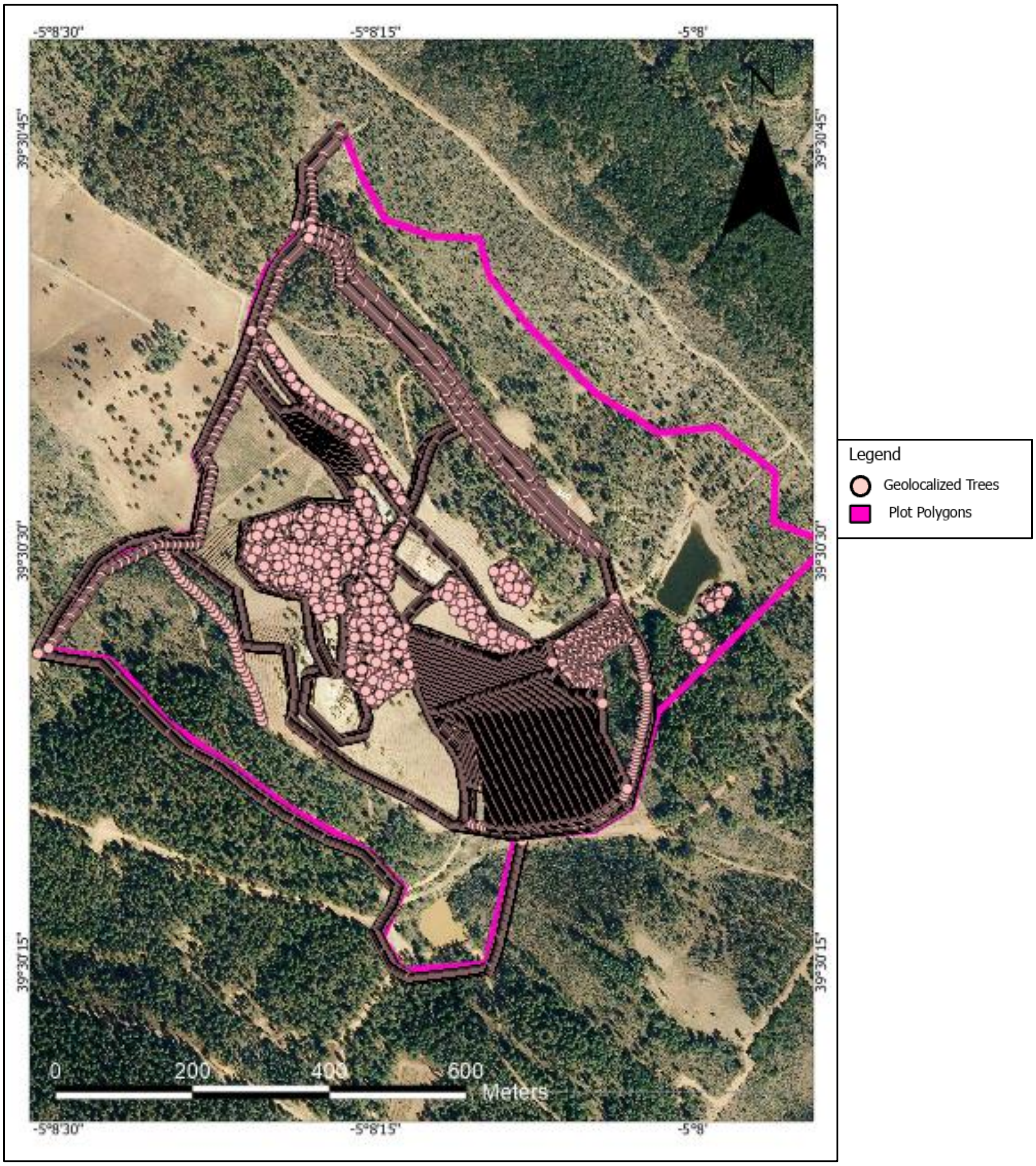


IMAGE 5. TREE PLANTING DISTRIBUTION

TABLE 3. TECHNICAL DATA SHEETS OF SPECIES USED FOR REFORESTATION

Acer pseudoplatanus • Also known as the sycamore is a large deciduous, broad-leaved tree, tolerant of wind and coastal exposure. It is native to Central Europe and Western Asia. • It can grow to a height of about 35 m with branches that form a broad, rounded crown. • It is tolerant of a wide range of soil types and pH, except heavy clay, and is at its best on nutrient-rich, slightly calcareous soils. • Roots of the sycamore form highly specific beneficial mycorrhizal associations with the fungus Glomus hoi, which promotes phosphorus uptake from the soil.	
Acer monspessulanum • Also known as the Montpellier maple, is a species of maple native to the Mediterranean region. • A medium-sized deciduous tree or densely branched shrub that grows to a height of 10-15 meters and a trunk diameter up to 75 cm. • Insensitive to limestone soils but does not support excess water. Thrives exclusively in hot and very dry contexts.	
Castanea sativa • Also known as the sweet chestnut or Spanish chestnut is a long-lived deciduous tree. • it produces an edible seed, the chestnut, which has been used in cooking. • It attains a height of 20–35 meters with a trunk often 2 meter in diameter. • The tolerance to wet ground and to clay-rich soils is very low however, it is a heat-loving tree which needs a long vegetation period. it may tolerate temperatures as low as -15 °C.	

Cupressus arizonica • A coniferous evergreen tree with a conic to ovoid-conic crown which grows to heights of 10–25 m and its trunk diameter reaches 55 cm. • It is widely cultivated as an ornamental tree. • It has proved highly resistant to cypress canker, hence growth is reliable where this disease is prevalent.	
Cupressus sempervirens • Also known as the Mediterranean cypress is a medium-sized coniferous evergreen tree which grows to 35 m tall. • Has been widely cultivated as an ornamental tree.	
Ficus carica • Also known as Fig is a decidious species of small tree in the flowering plant family Moraceae, native to the Mediterranean region, together with western and southern Asia. • Large shrub which grows up to 7–10 meters tall. • They tolerate moderate seasonal frost and can be grown even in hot-summer continental climates. • It prefers relatively porous and freely draining soil, and can grow in nutritionally poor soil.	

Genista cinerea • An ornamental shrub for banks and landscaping that can reach 1.5m. • It likes limestone, poor and well-drained soils.	
Genista scorpius • Genista scorpius is a species of shrub with compound, broad leaves and dry fruit. Individuals can grow to 2 m. • It can be used to create defensive hedges. • It generally grows in scrub in dry places, on clay, gypsum, limestone or marl substrates.	
Genista umbellata • Ornamental shrub for landscaping, Prefers poor stony and dry soils. • It reaches a size of up to 1.5 m in height.	
Lavandula angustifolia • It is a strongly aromatic shrub native to the Mediterranean growing as high as 1 to 2 metres tall. • Commonly grown as an ornamental plant. with its ability to survive with low water consumption. • It does best in Mediterranean climates • It tolerates acid soils but favours neutral to alkaline soils,	

Lavandula stoechas • Also known as the Spanish lavender native to several Mediterranean countries. • An evergreen shrub that usually grows to between 30 and 100 cm tall and occasionally up to 2 m. • it is associated with hot, dry, sunny conditions in alkaline soils.	
Morus nigra • Also known as black mulberry is a deciduous tree growing to 12 metres tall by 15 m broad. • The fruit is edible and the tree has long been cultivated for this property.	
Populus nigra • Commonly known as Black poplars are medium- to large-sized deciduous trees, reaching 20–30 m, and rarely 40 m tall and their trunks achieve up to 1.5 m in diameter, • Used in industrial areas and for row and landscape planting. • This tree is very resistant to cold, can live 400 years.	
Prunus avium ● Commonly called wild cherry, or sweet cherry, is a species of cherry. ● It is a deciduous tree growing to 15–32 meters tall, with a trunk up to 1.5 m in diameter. ● It is often cultivated as a flowering tree.	

Prunus dulcis • Commonly known as Almond is a species of tree native to Iran and surrounding countries however prospers in a moderate Mediterranean climate with warm, dry summers and mild, wet winters. • A deciduous tree growing to 4 –12.2 meters in height with a trunk of up to 30 centimeters.	
Prunus mahaleb • Also known as the mahaleb cherry is a species of cherry tree native to central and southern Europe, Iran and parts of central Asia. • It is a deciduous tree or large shrub, growing to 2–10 m (rarely up to 12 m) tall with a trunk up to 40 cm diameter. • The species is grown as an ornamental tree for its strongly fragrant flowers,	
Quercus pyrenaica • Also known as Pyrenean oak, or Spanish oak is a tree native to southwestern Europe and northwestern North Africa. • A tall deciduous tree, often marcescent in immature individuals, up to 25 metres tall, and has an average lifespan of 300 years. • It is adapted to survive in hot local temperatures.	

Quercus rubra • Also known as the northern red oak native of North America, which grows to to 28 meters tall with a trunk, up to 2 m in diameter. • It prefers good soil that is slightly acidic.	
Taxus baccata • Known as European yew is a species of evergreen tree in the family Taxaceae, native to Western Europe, Central Europe and Southern Europe. • Grows to 10–20 m (exceptionally up to 28 m) tall, with a trunk up to 2 m (exceptionally 4 m) in diameter. • The entire yew bush is poisonous with the exception of the aril (the red flesh of the berry covering the seed).	

III.1.3. REFORESTATION TECHNIQUE

The reforestation technique implemented is the Dense Planting/ Intensified Planting technique. Dense planting technique, also known as high-density planting or intensive planting, refers to a method of crop cultivation where plants are spaced closely together in order to maximize productivity and yield. Instead of the traditional practice of leaving significant spaces between plants, dense planting involves reducing the interplant spacing, resulting in a higher number of plants per unit area. The goal of this technique is to optimize the use of available resources, such as sunlight, water, and nutrients, by creating a more efficient growing environment. By reducing the space between plants, several benefits can be achieved which include enhanced resource utilization, weed suppression, and increased yield. Nonetheless, it is important to note that the success of dense planting depends on various factors, such as the specific plants being grown, local climate conditions, soil fertility, and management practices. Adequate irrigation, nutrient management, and careful monitoring of tree health are crucial to ensure optimal growth and prevent issues such as overcrowding, nutrient deficiencies, or increased disease susceptibility.

III.1.3.1. Methodological process

The operational phase is divided into three steps shown in Image 6.

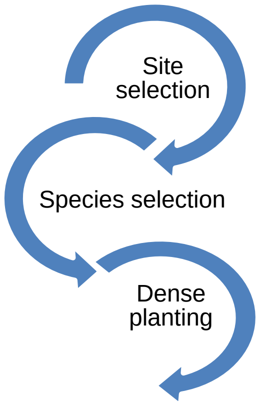


IMAGE 6. METHODOLOGICAL PROCESS

The reforestation process involved a well-defined series of steps. Firstly, a thorough evaluation was conducted to select the most suitable reforestation area, taking into account restoration needs, climatic and soil feasibility, permit requirements, and cost considerations. It ensured that the chosen location was conducive to successful reforestation. Previous individuals of Pinus spp. and Eucalyptus globulus were removed to make space for the new selection of species. To preserve the ecological integrity of the region, afforestation was not carried out on scarified ground. This approach aimed to leverage the existing ecosystem to facilitate the growth and development of the newly planted trees, promoting biodiversity and increasing the chances of successful reforestation. Local community stakeholders were actively involved in the process, fostering a sense of ownership and sustainability in the reforestation initiative.

III.1.4. GEOLOCALIZATION OF PLANTED TREES

Using Spatial Analyst tools in ArcGIS Pro environment, a detailed count of geolocalized trees was conducted within the project plot. The results indicate the distribution of 60,717 trees within the reforested plot spaced at approximately 3.6 meters intervals for larger tree species and 0.3 meter intervals for smaller shrubs as illustrated in Image 5 above.

This analysis provides valuable insights into the spatial relative abundance of trees within each plot. The distribution percentages highlight the varying densities and concentrations of trees, indicating areas with higher and lower tree populations in cases where the reforested plots are segmented. These findings help understand tree distribution and estimate the project's carbon absorption capacity. The number of trees and their carbon sequestration capacity are crucial for the estimation of the Project’s carbon sequestration potential. The count of geolocalized trees provides an overall measure, serving as a basis for estimating carbon sequestration. Combining tree count with species-specific data allows the estimation of biomass and carbon capture potential. This provides a quantitative assessment of the project's capacity to absorb and sequester CO_2.

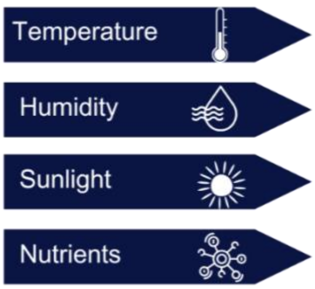
III.1.5. PROJECT CAPACITY

This section determines the project's and the area's capacity to absorb CO_2 using Net Primary Productivity (NPP) as a reference parameter. Then, the amount of CO_2 that can be captured is estimated with allometric equations taking into account the age and height of each species.

III.1.5.1. Net Primary Productivity (NPP)

Net Primary Productivity (NPP) is the result of organic matter production through the process of photosynthesis. However, primary productivity involves more than photosynthesis; it also encompasses the uptake of inorganic nutrients and the assimilation of diverse organic compounds into protoplasm, which are vital for all photosynthetic organisms. Among various ecosystem processes, NPP is extensively measured due to its ability to reflect carbon accumulation in ecosystems. The calculation of NPP is based on the increase in biomass per unit area over a specified time period.

NPP is influenced by several factors, including:



Hence, the net primary productivity (NPP) can be expressed as the difference between the carbon absorbed by vegetation through photosynthesis (referred to as Gross Primary Production or GPP) and the carbon lost through respiration. Temperature and precipitation are key limiting factors for

NPP, and it is generally assumed that NPP increases with both temperature and precipitation. However, it is important to note that the NPP can not exceed the saturation value of 3000 gDM/m^2/year (DM stands for dry matter).

For the calculation of NPP in the Alía Ecological Restoration project, the Miami methodology outlined in section "IV.1. aOCP Methodology for carbon removal and storage in vegetation" was employed. This methodology incorporates the following equations to determine NPP:

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

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 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

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

The maximum NPP acquired by the project in the plot amounts to 1,021.30. The breakdown is presented in Table 4. From this the biomass for the plot was computed with the formula;

Biomass = Total area * NPP (kg)

The total biomass expected to be developed yearly by the plots amounts to 332,916.62 kgC/yr. Results are presented in Table 4. It is important to note the calculation of biomass is based solely on the regions where tree planting occurred, potentially leading to a minor variance from the overall area indicated in the submitted forms.

TABLE 4. NPP AND BIOMASS CALCULATED FOR THE PLOT WITHIN THE PROJECT AREA

Plots	Net Primary Productivity (gC/m^2/yr)	Biomasa at plot level (KgC/yr)	CO_2 Capture at plot level (Kg CO_2/yr)
Plot 1	1021.30	391,588.37	1,437,131.52
Total		**391,588.37**	**1,437,131.52**

To calculate the amount of CO_2 that has been fixed in the plant biomass, we use the *"carbon to CO_2 emissions conversion factor"* of 3.67. For this, we use the following formula:

CO_2 = Biomass x 3.67

By utilizing the ratios of molar masses, we can deconstruct CO_2 and determine that it requires 3.67 kilograms of CO_2 to generate 1 kilogram of carbon within the tree. This is due to carbon having a molar mass of 12 and oxygen having a molar mass of 16. When combined as CO_2, the molar mass is 44. Consequently, 44/12 = 3.67. Applying the formula for converting biomass CO2 to carbon, we have derived the following result:

The total CO_2 fixed in the plant biomass for the plot of reforestation amounted to 166,705.77 kg/yr. The computation is illustrated below.

CO_2 = 391,588.57 ∗ 3.67 = 1,437,131.52 kgCO_2/year

Due to the ecosystem conditions (climatic and ecological) at the local level, it has been determined that **1,437.13 t CO2/year** will serve as a maximum limit parameter for the estimation of annual CO2 capture. This amount represents the maximum biomass generation capacity and, consequently, carbon sequestration.

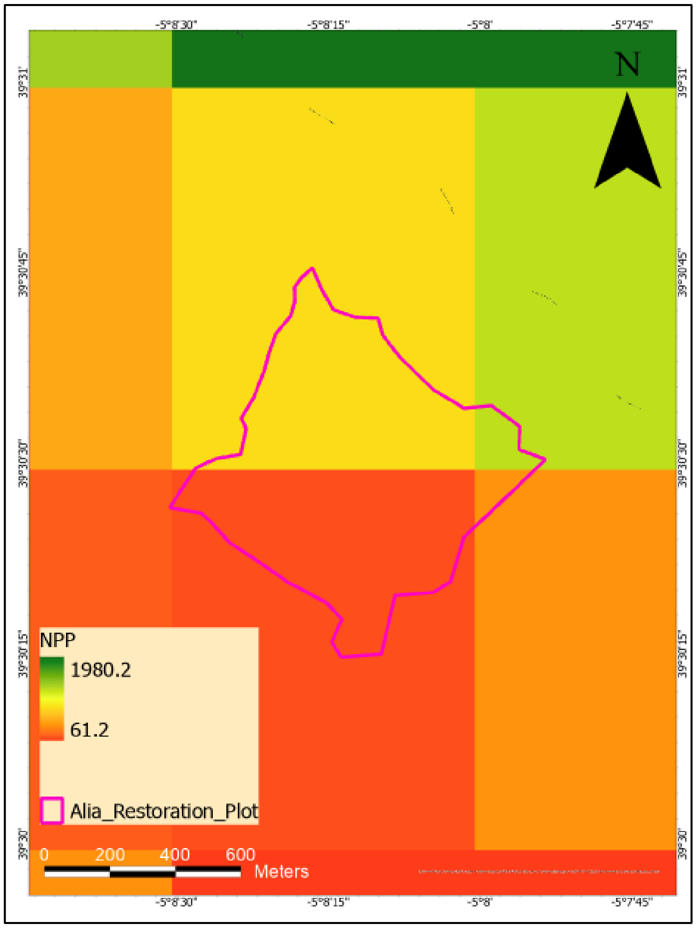


IMAGE 7. NET PRIMARY PRODUCTIVITY (NPP)

III.1.5.2. Allometric equations

Allometric equations are mathematical formulas used to estimate the amount of CO_2 that can be captured and stored in certain types of vegetation, such as trees or crops. Table 5 shows the allometric equations used for each reforestation species.

TABLE 5. ALLOMETRIC EQUATIONS

Species	Allometric equation Reference CO2 absorbed (Kg)	Reference
Acer monspessulanum	CO2 (kg) = 0,0405 x D^2,1412	S.G.A. Mommaerts, J. Hillemans, F. Franaux, and A. de Caluwé, 2015. “Alometric Equations for Estimating Carbon Sequestration in Corylus Avellana L. in Northwestern France,” Trees-Structure and Function, vol. 29, no. 5, pp. 1411–1420.
Acer pseudoplatanus	Biomass= 0.2286*DBH2.1639	References:Konôpka, B., Pajtík, J., & Šebeň, V. (2015). Biomass functions and expansion factors for young trees of European ash and Sycamore maple in the inner western Carpathians Biomassefunktionen und Expansionsfaktoren für junge Europäische Eschen und Bergahorne in den Inneren Westlichen Karpaten. Austrian Journal of Forest Science, 132, 1-26.
Castanea sativa	Biomass = 0.066 x DBH^ 2.647	Santa Regina, I. (2000). Organic matter distribution and nutrient fluxes within a sweet chestnut (Castanea sativa Mill) stand of the Sierra de Gata, Spain. Annals of forest science, 57(7), 691-700.
Cupressus arizonica	Carbon =(0.2637*(DBH)^1.7698)	Vigil, N. 2010. Estimación de biomasa y contenido de carbono en Cupressus lindleyi Klotzsch ex Endl. en el campo forestal experimental "Las Cruces", Texcoco, México. Tesis Profesional. Universidad Autónoma Chapingo. México. 61 p.
Cupressus sempervirens	Biomass = (0.5266*(DBH)^1.7712)	Vigil, N. 2010. Estimación de biomasa y contenido de carbono en Cupressus lindleyi Klotzsch ex Endl. en el campo forestal experimental "Las Cruces", Texcoco, México. Tesis Profesional. Universidad Autónoma Chapingo. México. 61 p.
Ficus carica	CO2 (kg) = 0.654 DBH (m)2 + 0.0452	Gressent, A., Luc, D., Nowak, D. et al. CO2 capture of Ficus carica in France and its climate dependence: Allometric relations and environmental control. Urban For Urban Green 25, 49–59 (2017). https://doi.org/10.1016/j.ufug.2017.05.006
Genista cinerea	Biomass=5.7696*10^(-9)*((H)^(3.914))	Reference; Tietema, T. 1993. Biomass determination of fuelwood trees and bushes of Botswana, Southern Africa. Forest Ecology and Management 60: 257-269.
Genista scorpius	Biomass=5.7696*10^(-9)*((H)^(3.914))	Reference; Tietema, T. 1993. Biomass determination of fuelwood trees and bushes of Botswana, Southern Africa. Forest Ecology and Management 60: 257-269.
Genista umbellata	Biomass=5.7696*10^(-9)*((H)^(3.914))	Reference; Tietema, T. 1993. Biomass determination of fuelwood trees and bushes of Botswana, Southern Africa. Forest Ecology and Management 60: 257-269.
Lavandula angustifolia	Biomass=4*exp(-0.06*(H)^(3.1116))	Pande, P.K. 2005. Biomass and productivity in some disturbed tropical dry deciduous teak forests of Satpura plateau , Madhya Pradesh. Tropical Ecology, 46(2): 229?239.

Species	Allometric equation Reference CO2 absorbed (Kg)	Reference
Lavandula stoechas	Biomass=4*exp(-0.06*(H)^(3.1116))	Pande, P.K. 2005. Biomass and productivity in some disturbed tropical dry deciduous teak forests of Satpura plateau , Madhya Pradesh. Tropical Ecology, 46(2): 229?239.
Morus nigra	Biomass = Exp(-2.4800 + 2.4835 In dbh)	Reference; Speak, A., Escobedo, F. J., Russo, A., & Zerbe, S. (2020). Total urban tree carbon storage and waste management emissions estimated using a combination of LiDAR, field measurements and an end-of-life wood approach. Journal of Cleaner Production, 256, 120420.
Populus nigra	Biomass = 0.0194(D2H)0.9669	Hussain, M., & Ali, F. Assessing Carbon Sequestration Potential of Selected Woody Tree Species Growing in Hattar Industrial Estate, Haripur, Pakistan.
Prunus avium	Biomass = 0.12 x DBH^ 2.33	Alberti, G., Marelli, A., Piovesana, D., Peressotti, A., Zerbi, G., Gottardo, E., & Bidese, F. (2006). Carbon stocks and productivity in forest plantations (Kyoto forests) in Friuli Venezia Giulia (Italy). Forest@, 3, 488-495.
Prunus dulcis	Biomass = 0.12 x DBH^ 2.33	Alberti, G., Marelli, A., Piovesana, D., Peressotti, A., Zerbi, G., Gottardo, E., & Bidese, F. (2006). Carbon stocks and productivity in forest plantations (Kyoto forests) in Friuli Venezia Giulia (Italy). Forest@, 3, 488-495.
Prunus mahaleb	CO2 (kg) = 0.078 * DBH2.83	Sciubba, L., Monti, A., & Ginocchio, R. (2015). Carbon sequestration and storage in Prunus mahaleb trees in central Italy. iForest, 8(2), 83–90.
Quercus pyrenaica	Biomass = 0.00776 x (D2 H)1.0856	Bazrgar, A. B., Thevathasan, N., Gordon, A., & Simpson, J. (2023). Allometric Equations for Estimating Above-Ground Biomass Carbon sequestration in Five Tree Species grown in an Intercropping Agroforestry System in Southern Ontario, Canada.
Quercus rubra	Biomass = 0.00776 x (D2 H)1.0856	Bazrgar, A. B., Thevathasan, N., Gordon, A., & Simpson, J. (2023). Allometric Equations for Estimating Above-Ground Biomass Carbon sequestration in Five Tree Species grown in an Intercropping Agroforestry System in Southern Ontario, Canada.
Taxus baccata	CO2 (kg) = 0.000232 x (Tree Height^2) x (Tree Diameter^2)	2. Garrido-Garrido, M., Salazar, A., López-Gallego, C., Martí, D., & Garnatje, T. (2003). Allometry of aboveground biomass of Taxus baccata L. trees. European journal of forest research, 122(4-5), 199-206.

III.1.5.2. CO_2 Capture in vegetation

As a standard, the aOCP considers a planting density of 1 tree every four meters as a reference, since distributing the trees in this way allows each tree to have enough space to grow and develop adequately, avoiding excessive competition for resources such as sunlight, water, and soil nutrients. The reference density for this scenario is 16 square meters per tree. Currently, the project has achieved a density of 6.31 square meters per tree, far exceeding the planned reference density. This planting density has significant implications for the success of reforestation efforts. By providing adequate space for individual tree growth, it increases the chances of survival and healthy development. However, in this case, proper management practices will be essential to ensure optimal resource utilization, especially as trees grow and compete for sunlight, water, and nutrients. Maintaining the right balance between tree density and resource availability will be crucial to maintaining the health and productivity of the reforested ecosystem over time.

Avoiding competition for resources favors optimal access to sunlight for photosynthesis, sufficient water uptake and efficient nutrient uptake from the soil, as defined by Net Primary Productivity (NPP). These factors are crucial for the establishment of a sustainable and resilient forest ecosystem.

In order to maintain the conservative method in the calculation, three scenarios of survival of the planted individuals will be made: optimistic scenario 80%, intermediate scenario 50% and pessimistic scenario 30%. Resulting in the optimistic scenario (survival 80%) at year 40 of the project the number of trees would be 48,574. In the intermediate scenario (50% survival) it would be 30,359 trees and in the pessimistic scenario (30% survival) it would be 18,215 trees (Image 7).

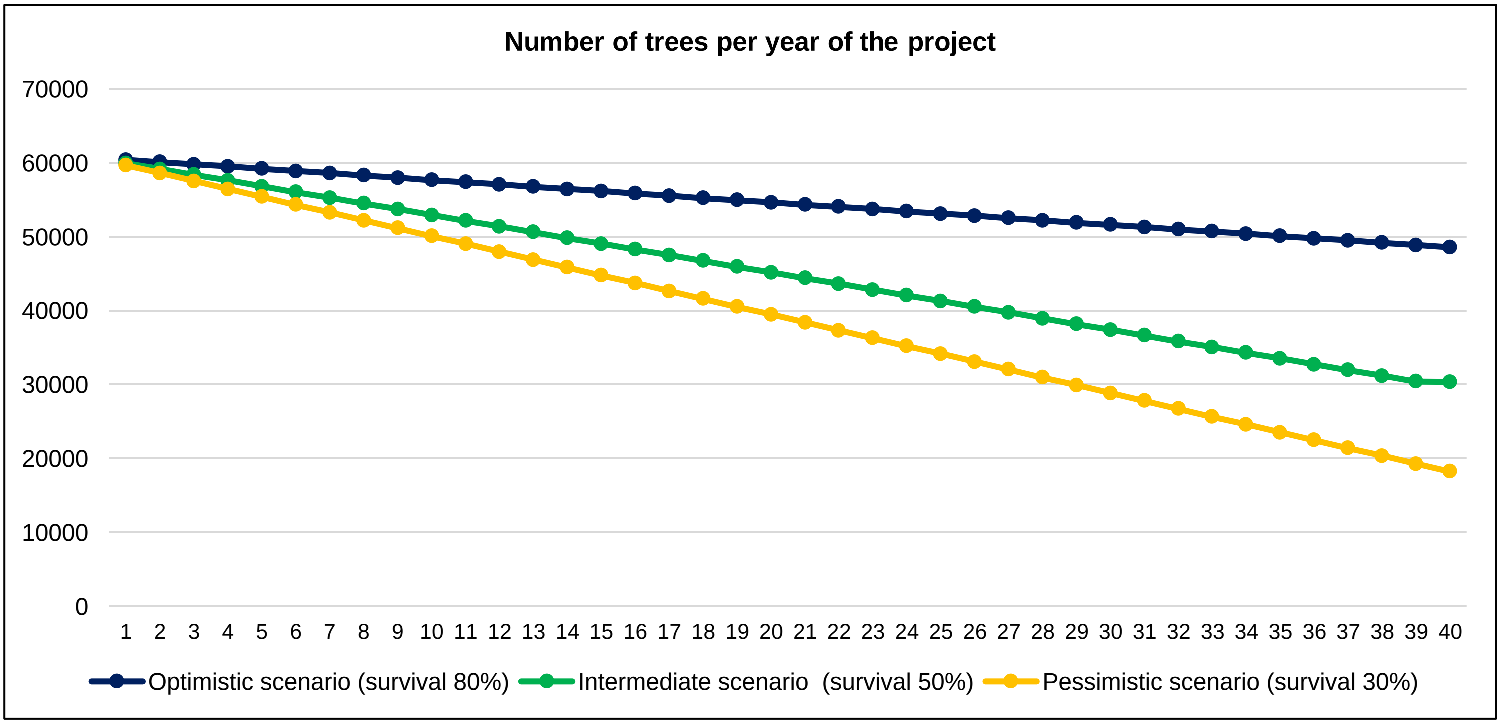


IMAGE 8. SURVIVAL RANGE IN THREE SCENARIOS

With the above results, the calculation of carbon sequestration will be made using the following formula.

Project CO2 capture (tn) =

((Biomass available * 3.67) * 0.45) * m^2 available per tree * number of trees / 1000 * number of project years

Where:

Project CO_2 capture (tn) = ((1.02*3.67)*0.45) * 6 * 60717 / 1000 * 40 = **24,547**

A maximum capture capacity of 24,547 tons of CO_2 was estimated; to maintain a conservative calculation, the capture has been estimated in three scenarios: optimistic (survival 80%), intermediate (survival 50%), and pessimistic (30%):

TABLE 6. CARBON SEQUESTRATION CALCULATION

Scenario	Surival range	CO2 capture (tn)
Optimistic	80%	19,637.60
Intermediate	50%	12,273.50
Pessimistic	30%	7,364.10

In the Project Submission Form (PSF), the proponent has declared an expected capture of 15,568 tons of CO_2 (attaching the calculation methodology), which represents 63.42% of the maximum capture capacity. To maintain a conservative scenario, derived from the benefits of the project, **19,637 carbon removal credits** (corresponding to the scenario optimistic) will be granted.

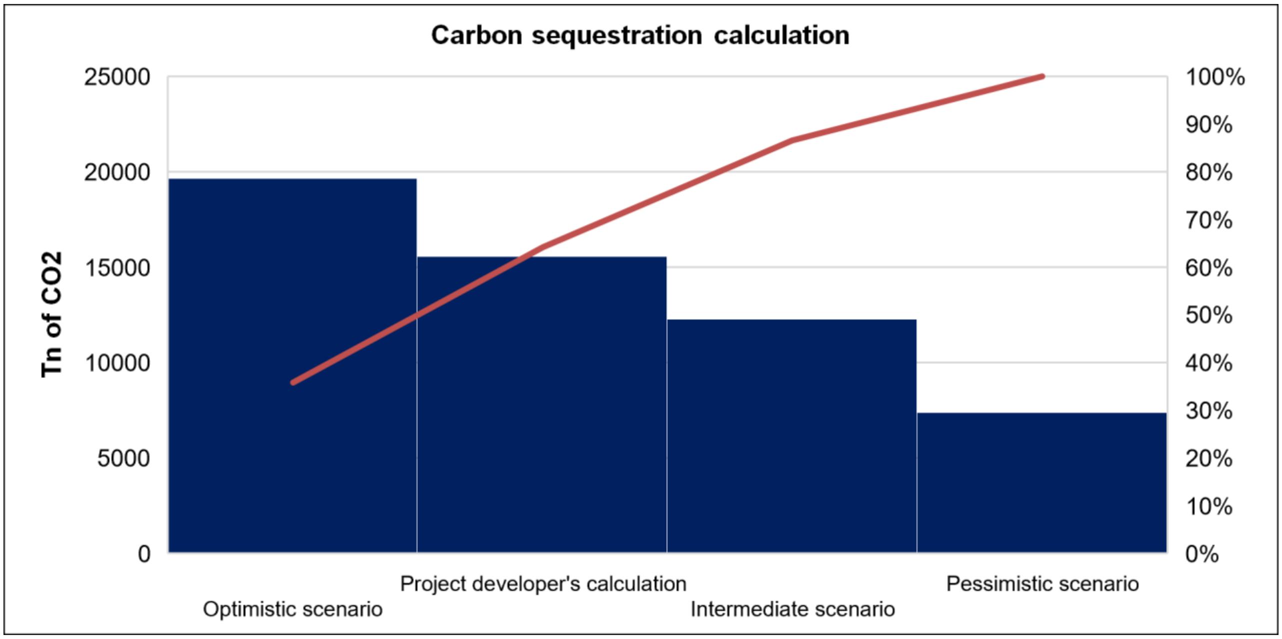


IMAGE 9. CARBON SEQUESTRATION CALCULATION

As established in section *III.1.2.* of the *Procedures document version 2.0*, **20%** of the credits generated by the project will be withdrawn for the buffer pool as a measure to guarantee the permanence of the project benefits (3,927 credits), resulting in a total of **15,710 carbon removal credits** to be issued according to the Contingency Table (Table 7).

TABLE 7. CONTINGENT TABLE VCCS

Carbon removal credits issued annually												
Project Size (total GHG reductions & removals)	**Percentage of VCCs issued on each year (%)**											
	After project implementation	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**Total**
Percentage of VCCs issued on each year (%)	30%	9%	9%	8%	8%	6%	6%	6%	6%	6%	6%	**100%**
Number of VCCs issued each year	4,666	1,458	1,455	1,255	1,255	1,005	940	940	912	912	912	**15,710**

III.2. BIODIVERSITY

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.

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

The method followed 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:

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

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

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

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 index factor through Shannon. The areas restored are those created thanks to the construction of the project and their measurement will also consider the surface area factor (in m^2) and the diversity index factor measured with Shannon. Finally, the ecological condition variable of the intervened area is formulated by five factors that together will allow evaluation of the state of the ecosystem impacted by the project, taking into account the following:

- **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.

Once each one 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 formula incorporates the relativized factors, Shannon index values, benefits adjacent to the ecosystem and the areas of each variable to calculate the biodiversity credit. 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.

One of the most widely used indices to quantify specific biodiversity is the Shannon index, also known as Shannon-Weaver (Shannon and Weaver, 1949), derived from information theory 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, and 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:

Pi (p_1,p_2, p_3… p_s*) = It is the relative abundance of target 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 $\boldsymbol{i}$= It is the abundance of the category i

n= It is the abundance of all categories of the sample

The diversity is influenced by the distribution of the objects in the categories. The evenness (J) is calculated as follows:

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

Where:

D= This is the diversity

Dmax= This is the maximum diversity that can be expressed through the sample

The following is a description of the variables of the Alía ecological restoration project, which will subsequently be ranked in the corresponding relativized value.

III.2.1. PROJECT EVALUATION VARIABLES

III.2.1.1. Preserved area variable

The preserved area corresponds to the area within the property boundary of the property where the project activities were carried out (383,421.50 m^2), subtracting the plantation area (99,371.66 m^2), resulting in a conservation area of 284,050 m^2 (Image 10ß).

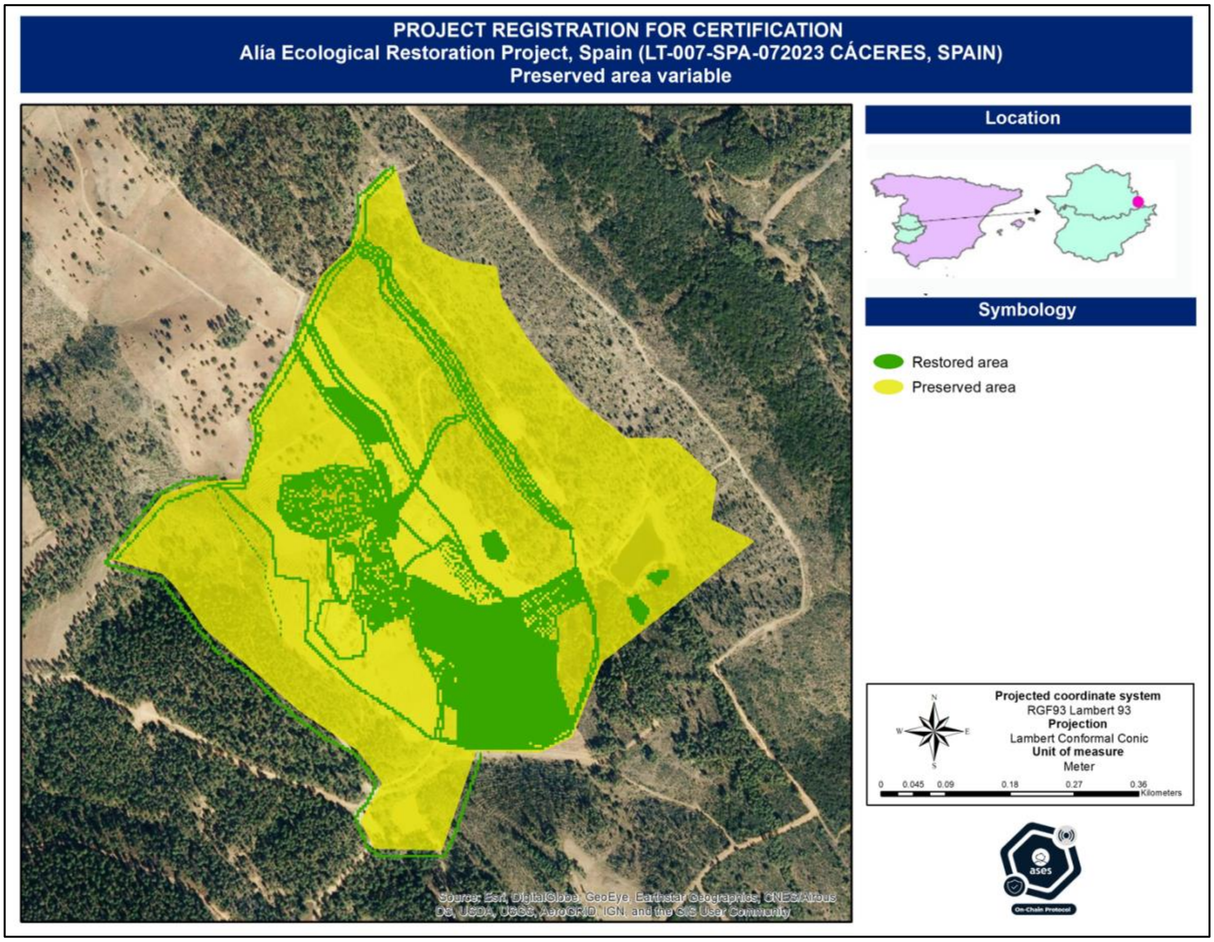


IMAGE 10. PRESERVED AREA VARIABLE

The results of the preserved flora and fauna indices are presented below.

III.2.1.1.1. Flora

To calculate the biodiversity index of the flora present in the study area, a count of the trees and shrubs present was made by sampling 8 fixed points each with an area of 100 m^2 (Image 11).

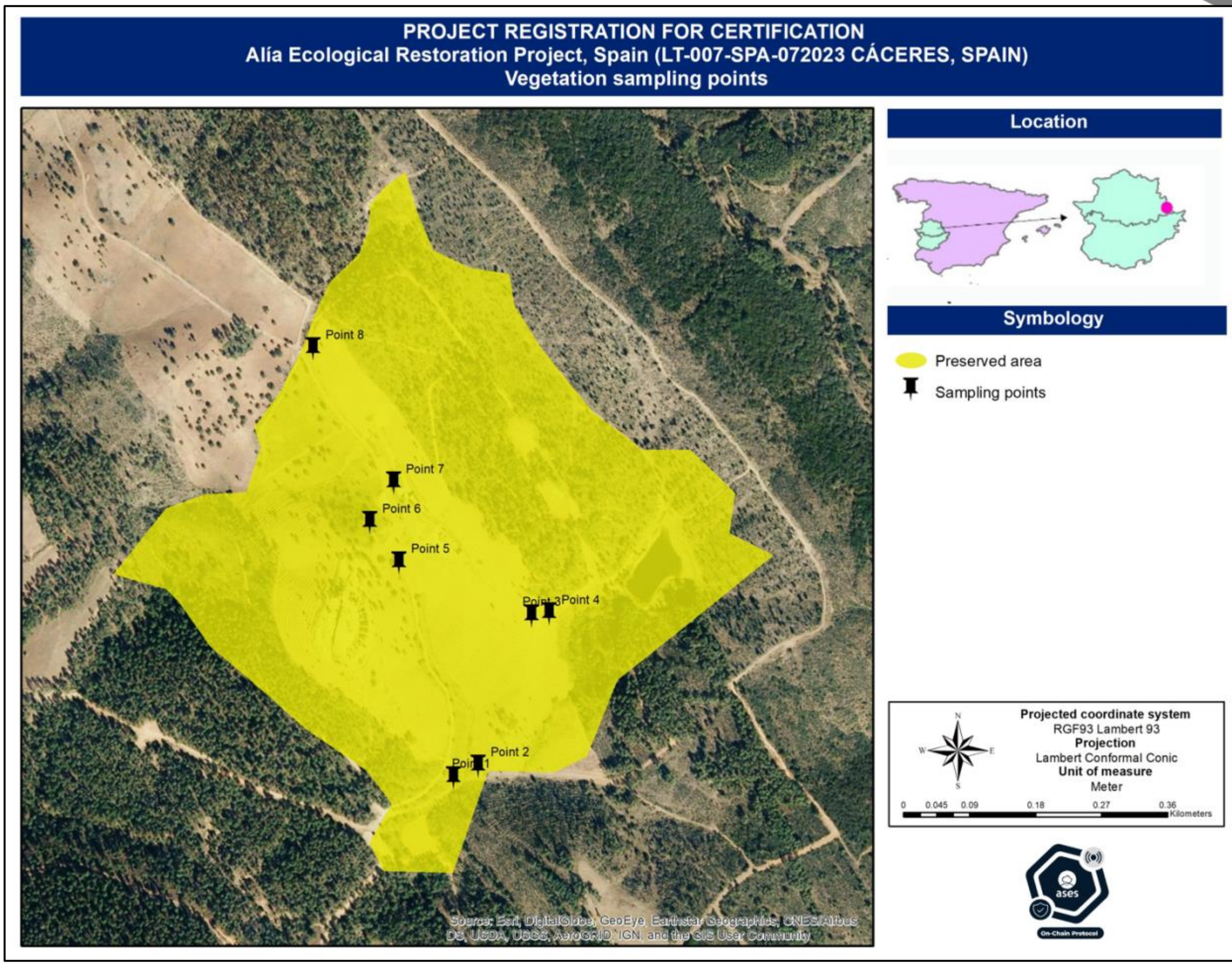


IMAGE 11. VEGETATION SAMPLING POINTS

The count resulted in the presence of 186 individuals of 23 different species (Table 8).

TABLE 8. PLANT SPECIES PRESENT IN THE COUNTING AREA

Especie	Individuos
Amaranthus albus	2
Anisantha diandra	22
Anthemis maritima	2
Anthriscus caucalis	1
Bituminaria bituminosa	1
Brachypodium distachylon	71
Centaurea melitensis	2
Chondrilla juncea	3
Cistus ladanifer	10
Cynara humilis	7
Cynosorus cristatus	2
Dysphania pumilio	1

Especie	Individuos
Granado	2
Heliotropium europaeum	1
Lavandula angustifolia	7
Lenton tuberosus	1
Phyllirea angustifolia	8
Quercus coccifera	22
Quercus ilex	4
Reichardia picroides	1
Taraxacum obovatum	1
Thymus mastichina	1
Vulpia cilicata	14

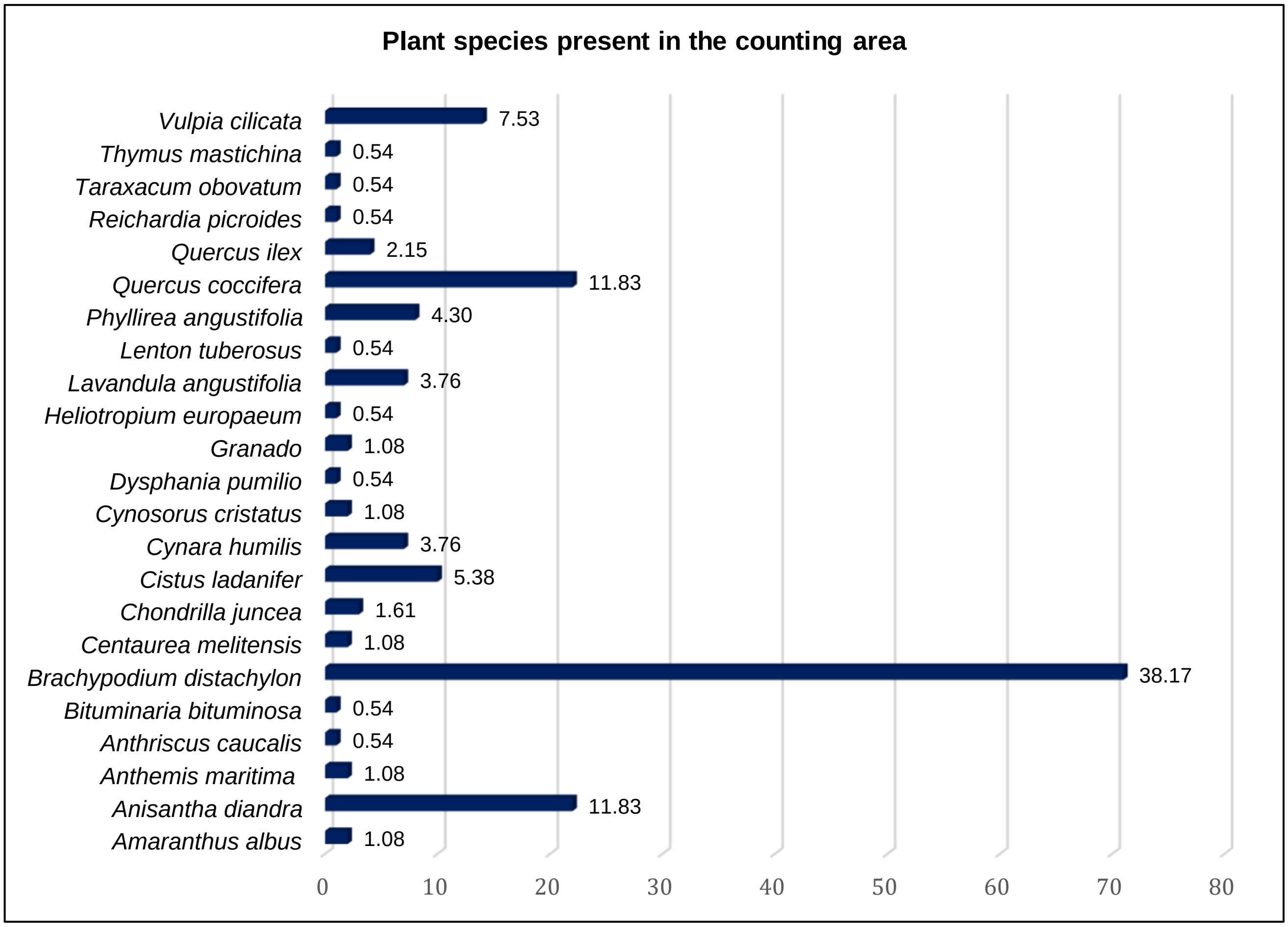


IMAGE 12. PLANT SPECIES PRESENT IN THE COUNTING AREA

The results of specific richness, Shannon-Weaver diversity index, maximum diversity, and evenness of the tree and shrub community in the project conservation area are shown in Table 9.

TABLE 9. BIODIVERSITY PARAMETERS OF THE FLORA BIODIVERSITY IN THE PRESERVATION AREA

Parameters of flora diversity index	Preservation area
Species richness	23
Diversity (nats)	2.22
Maximum potential diversity (Hmax)	3.13
Equitability index (J)	0.70

When the value of the diversity index is 0, there is only one category, i.e., there is no diversity; and the index increases as the number of objects or classes increases or if the proportional distribution of the occupied area among the types of ecosystems or objects, species, etc., is more equitable. For the preservation area, a flora diversity index of 2.22 was obtained, which could be interpreted as a **high diversity** according to the categories presented in Table 10.

TABLE 10. 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).

III.2.1.1.2. Fauna

During the fauna sampling carried out in the project area, a total of 70 individuals of 16 different species were recorded, of which 80% are birds, 15.71% mammals and 4.29% reptiles (Table 11).

TABLE 11. REGISTERED FAUNA

Scientific name	Common name	Number
Birds		
Ciconia ciconia	White stork	4
Ardea cinerea	Gray Heron	1
Passer domesticus	House Sparrow	13
Hirundo rustica	Barn Swallow	9

Scientific name	Common name	Number
Ptyonoprogone rupestris	Eurasian crag martin	7
Cyanistes caeruleus	Eurasian Blue Tit	5
Motacilla alba	White Wagtail	4
Parus major	Great Tit	5
Erithacus rubecula	European Robin	3
Corvus corax	Common Raven	2
Cecropis daurica	Red-rumped Swallow	2
Bubulcus ibis	Cattle Egret	1
Mammals		
Cervus elaphus	Red Deer	9
Vulpes vulpes	Red Fox	1
Crocidura spp	Musk Shrews	1
Reptiles		
Psammodromus algirus	Large Psammodromus	3

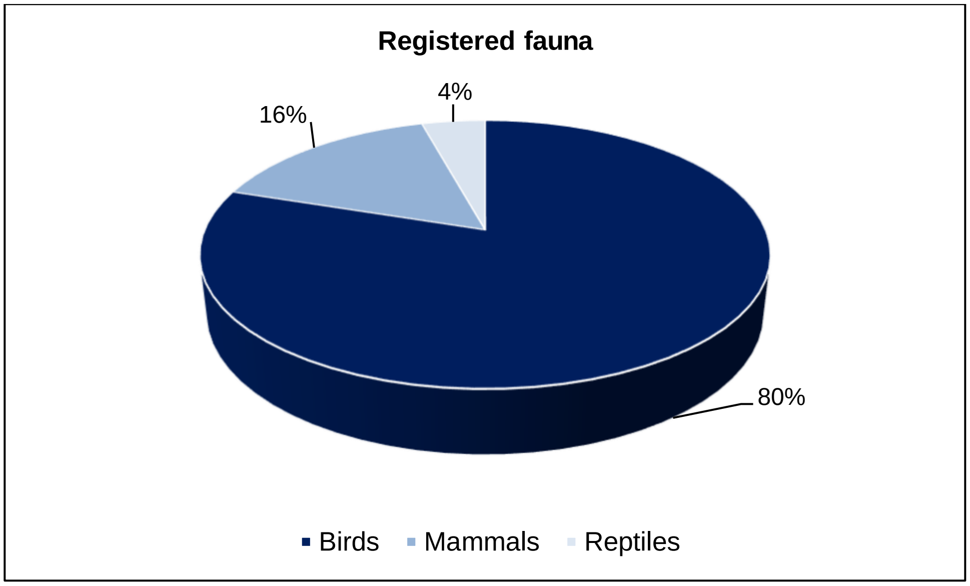


IMAGE 13. REGISTERED FAUNA

The results of the specific richness, Shannon-Weaver diversity index, maximum diversity, and evenness of the fauna in the project conservation area are shown in Table 12.

TABLE 12. BIODIVERSITY PARAMETERS OF THE FAUNA BIODIVERSITY IN THE PRESERVATION AREA

Parameters of flora diversity index	Preservation area
Species richness	16
Diversity (nats)	2.49

Parameters of flora diversity index	Preservation area
Maximum potential diversity (Hmax)	2.77
Equitability index (J)	0.89

According to Table 10 Qualitative categories of interpretation of the Shannon index, the index value obtained would be categorized as **high** diversity**.**

In order to know the general biodiversity index of the conservation area, the index was calculated for all species recorded in this area, including flora and fauna, resulting in a diversity of 2.88, which could be interpreted as a **very high diversity** according to the categories in Table 10.

TABLE 13. BIODIVERSITY PARAMETERS IN THE PRESERVATION AREA

Parameters of flora diversity index	Preservation area
Species richness	39
Diversity (nats)	2.88
Maximum potential diversity (Hmax)	3.66
Equitability index (J)	0.78

III.2.1.2. Restored area variable

The area restored corresponds to the 383,421.50 m^2 where the activities of the project were carried out. To evaluate this parameter, the benefits of reforestation were calculated through the diversity index, considering the 60,717 new trees of 19 different species that were planted (Table 14).

TABLE 14. BIODIVERSITY PARAMETERS IN THE RESTORED AREA

Parameters of flora diversity index	Restored area
Species richness	19
Diversity (nats)	2.01
Maximum potential diversity (Hmax)	2.94
Equitability index (J)	0.68

According to Table 10 Qualitative categories of interpretation of the Shannon index, the index value obtained would be categorized as **medium** diversity**.**

III.2.1.3. Ecological condition of the intervened zone

III.2.1.3.1. 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.

Bats contribute to health and ecological balance by providing various environmental services such as pollination, seed dispersal, pest control, and thus disease reduction. Their presence and conservation are necessary to maintain biodiversity, ecological harmony, and the healthy functioning of ecosystems.

From the ultrasonic recorders for bats installed in the project area, the presence of four species was identified, one of which is classified as Vulnerable (VU) by the global Red List *(Miniopterus schreibersii)* (Table 15).

TABLE 15. RECORDED BAT SPECIES

Species	Pulses	Protection category*		Distribution
Eptesicus nilssoni	2	LC	Least Concern	Native
Miniopterus schreibersii	11	VU	Vulnerable	Native
Pipistrellus nathusii	7	LC	Least Concern	Native
Tadarida teniotis	521	LC	Least Concern	Native

To evaluate this factor, the diversity index of these four key species was calculated (Table 16), resulting in a diversity of 0.19, which according to Table 10 Qualitative categories of interpretation of the Shannon index, would be categorized as a **very low diversity.**

TABLE 16. RECORDED BAT SPECIES

Diversity parameters	Protection of key species
Species richness	4
Diversity (nats)	0.19
Maximum potential diversity (Hmax)	1.38
Equitability index (J)	0.13

III.2.1.3.2. Fragmentation

For greater precision, the fragmentation analysis was carried out at the microbasin scale because this scale of study allows the integration of the different elements of the landscape such as vegetation, hydrology, and land use patterns. The microbasin delimited for the project area has a total area of 26,654 ha.

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)

To determine the area of forest within the microbasin, the areas with forest vegetation were digitized using a satellite image. As a result, 73% (19,533.56 ha) of the microbasin has natural vegetation (Image 14).

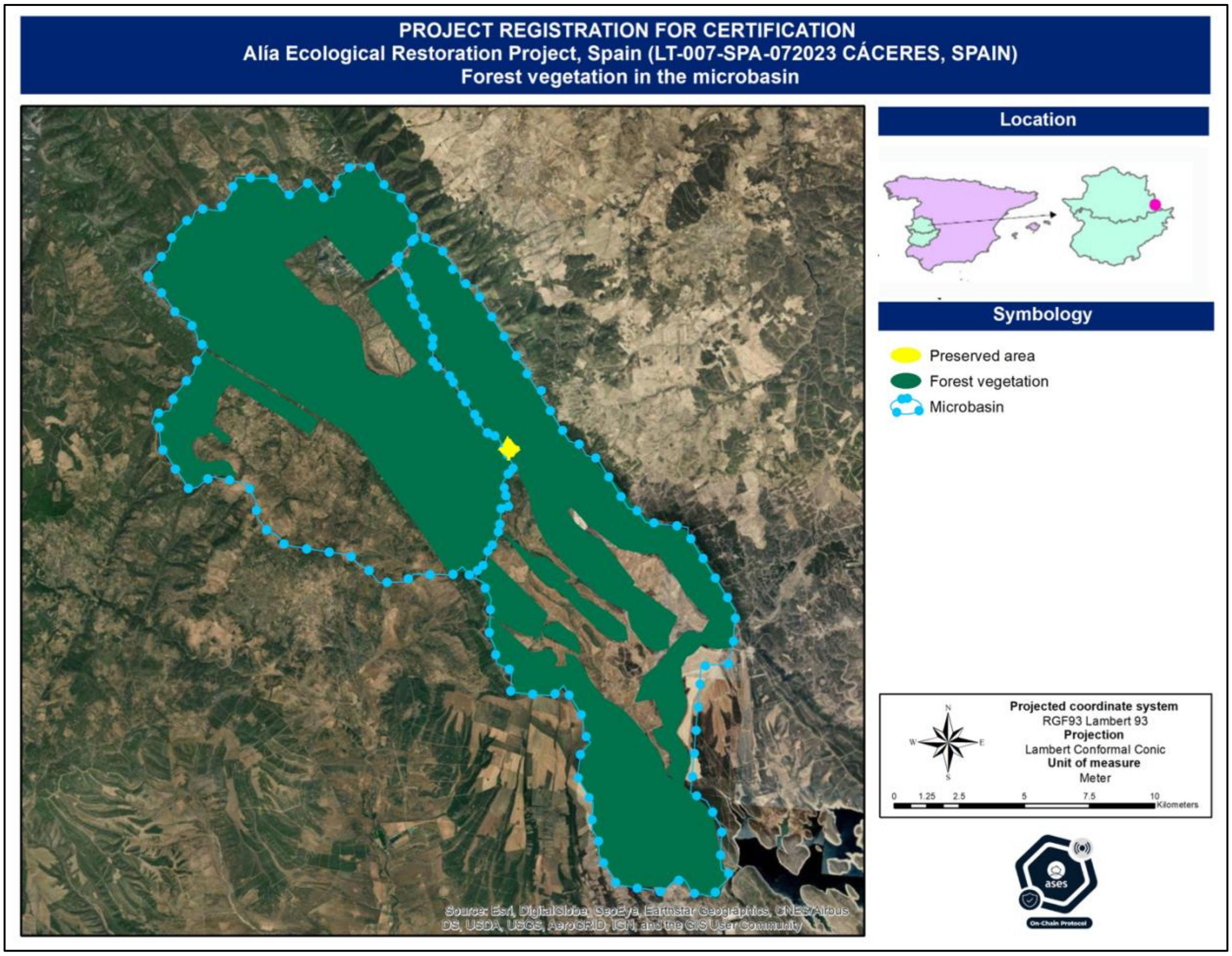


IMAGE 14. FOREST VEGETATION IN THE MICROBASIN

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 17).

TABLE 17. FRAGMENTATION RANGE

Fragmentation range	Level
<0.5	Insularized
0.5 – 0.7	Highly fragmented
0.7 – 0.9	Moderate fragmentation

Fragmentation range	Level
1	Without fragmentation

Bibliographical source: Díaz, A (2003)

Therefore, applying the formula to the project landscape resulted in the following:

Fragmentation = 19,533.56 / 26,654.60 = **0.73**

The fragmentation index was 0.87, which indicates that the microbasin has a **moderate degree** of fragmentation.

III.2.1.3.3. 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.

For the Alia Ecological Restoration Project, the fractal dimension index was calculated with the Landscape Ecology Statistics (LecoS) plugin of QGIS, which was modeled at the micro-watershed scale and used as input for the forest area in raster format.

The result obtained was **1.1022** which indicates that the landscape structure has a **round** perimeter (Table 18).

TABLE 18. 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

III.2.1.3.4. SPATIAL CONTINUITY

For the evaluation of spatial continuity as an indicator of fragmentation, the Volgelmann Index (FCI) applied at the micro-watershed scale of the project was used. The formula is made up as follows:

$$\textbf{FCI} = \ln (\Sigma A / \Sigma P)$$

Where:

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 (Tabla 19).

TABLE 19. SPATIAL CONTINUITY

Index value	SPATIAL CONTINUITY
< 0	Continuous
0.10 - 5	Discontinuous
> 5	Highly discontinuous

The total area of forest patches in the project's microbasin landscape is 195,335,640.74 m^2 (Image 13) and its perimeter is 252,503.25 m, which applied to the above formula gives a result:

FCI = ln (195,335,640.74 / 252,503.25) = **6.65**

The level of spatial continuity in the project's micro basin is 6.65, classified as **highly discontinuous** according to Table 19.

III.2.1.3.4. Ecosystem vulnerability to climate change

Biomass is fundamental to sustaining species diversity in ecosystems, and its reduction could lead to a decrease in habitats and resources available for species, which would have a direct impact on biological diversity.

Vulnerability to climate change is a very relevant factor to consider, and its evaluation will be carried out using the biomass data presented and described in section III.1.1.5.1 Net Primary Productivity (NPP) for the current scenario, which is **391,588.37 kgC/y**r.

Since climate change will lead to changes in ecosystem conditions, the ability of ecosystems to sequester CO_2 will also be affected. Therefore, we have also calculated the NPP and biomass for the year 2050 with the climate change scenario. As a result, we have obtained that the local ecosystem will have a net primary production of **699.05 gC/m2/yr**, which is equivalent to a biomass of **268,030.80 kgC/yr.** This indicates a decrease of **123.55 tn/yr** of biomass in the year 2050.

III.2.1.3.5. Species vulnerability to climate change

The vulnerability to climate change of the reforested species was evaluated based on the current and future potential distribution models (2050 RCP 45) 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 has with respect to the ecological (temperature, precipitation, etc.), physical (altitude) and biological (vegetation) needs that each planted species requires to ensure its adaptability and survival.

Table 20 indicates the probability of presence of the planted species, based on the ecological conditions that the area will have in 2050 in response to climate change.

TABLE 20. SPECIES VULNERABILITY TO CLIMATE CHANGE

Species	Percentage of required conditions in the project area	
	Current	**2050**
Acer monspessulanum	92.58	34.72
Acer pseudoplatanus	75.44	42.58
Castanea sativa	96.75	42.58
Cupressus arizonica	96.75	43.50
Cupressus sempervirens	92.58	76.39
Ficus carica	97.22	51.39
Genista cinerea	97.22	65.28
Genista scorpius	94.44	39.33
Genista umbellata	91.67	76.83
Lavandula angustifolia	53.22	24.06
Lavandula stoechas	97.22	44.44
Morus nigra	58.78	56.94
Populus nigra	91.19	42.58
Prunus avium	96.28	32.86
Prunus dulcis	96.75	59.25
Prunus mahaleb	87.03	62.50
Quercus pyrenaica	96.75	30.56
Quercus rubra	77.22	48.14
Taxus baccata	65.28	43.50
Average	**87.07**	**48.29**

As can be seen in the table above, currently the project area has on average 87.07% of all the necessary ecological conditions of the reforested species, and in 2050 the percentage will decrease to 48.29%, i.e. **-38.78%** of the conditions, indicating that the planted species have a **medium resilience** to the effects of climate change.

III.2.2. CLASSIFICATION OF RELATIVIZED VARIABLES

Factor		Value obtained for the project	Clasification	Value index	Relativized factor
F1	Biodiversity index of key protected species	0.19	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
F2	Fragmentation	0.73	Insularized	<0.5	0.2
			Highly fragmented	0.5 – 0.7	0.33
			Moderate fragmentation	0.7 – 0.9	0.66
			Without fragmentation	1	1
F3	Fractal dimension	1.1022	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	6.65	Continuous	< 0	1
			Discontinuous	0.10 - 5	0.02
			Highly discontinuous	> 5	0.01
F5	Ecosystem vulnerability to climate change	123.55	Very low	0 - 10	1
			Low	10 - 50	0.67
			Medium	50 - 100	0.33
			High	100 - 500	0.16
			Very high	> 500	0.11
F6	Species vulnerability to climate change	38.78	Species with very high resilience	<10	1
			Highly resilient species	10 a 20	0.72
			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	2.01	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

Factor		Value obtained for the project	Clasification	Value index	Relativized factor
F8	Biodiversity index in the preserved area	2.88	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

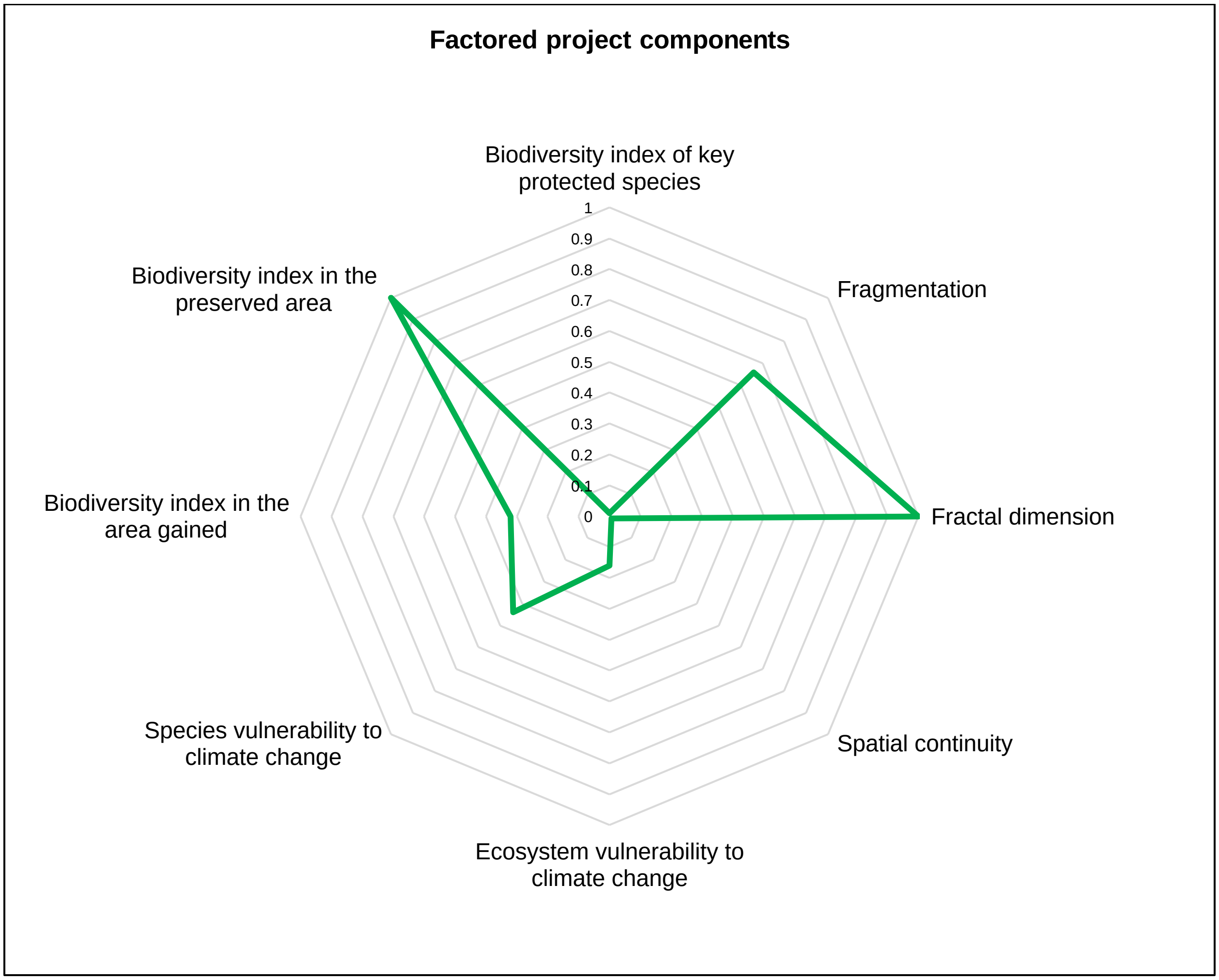


IMAGE 15. FACTORED PROJECT COMPONENTS

Once the indices for each factor and their relativization were obtained, the formula proposed for the calculation of biodiversity credits was applied, obtaining a total of **11,900 biodiversity credits VBBC** for the Ecological restoration project in Alía, Spain, which will be issued according to the monitoring plan and the contingent table.

$$\mathbf{VBBCs} = \frac{383421.5*(0.01+0.66+1.00+0.16+0.01+0.44)+(99371.66*0.32)+(284050*1)}{100} = \mathbf{11900}$$

It is considered **11,900** is the number of biodiversity credits that could be awarded by the Alía ecological restoration project based on the benefits it has generated in terms of diversity.

To estimate the maximum number of credits to which the project could aspire, a simulation was carried out considering that the variables analyzed would have a greater positive response to the different factors evaluated throughout the life of the project. That is if during the monitoring determined in the Monitoring Plan, results are obtained that demonstrate that the biodiversity index measured with Shannon significantly increased for the preserved area and key species, in addition to demonstrating that fragmentation decreased and therefore the fractal dimension, and that the project improved the spatial continuity of the landscape.

Once the above-mentioned variables have been ranked with the factor relativized to the maximum probable, it is determined that the Alía ecological restoration project could reach a maximum of **19,530 credits.**

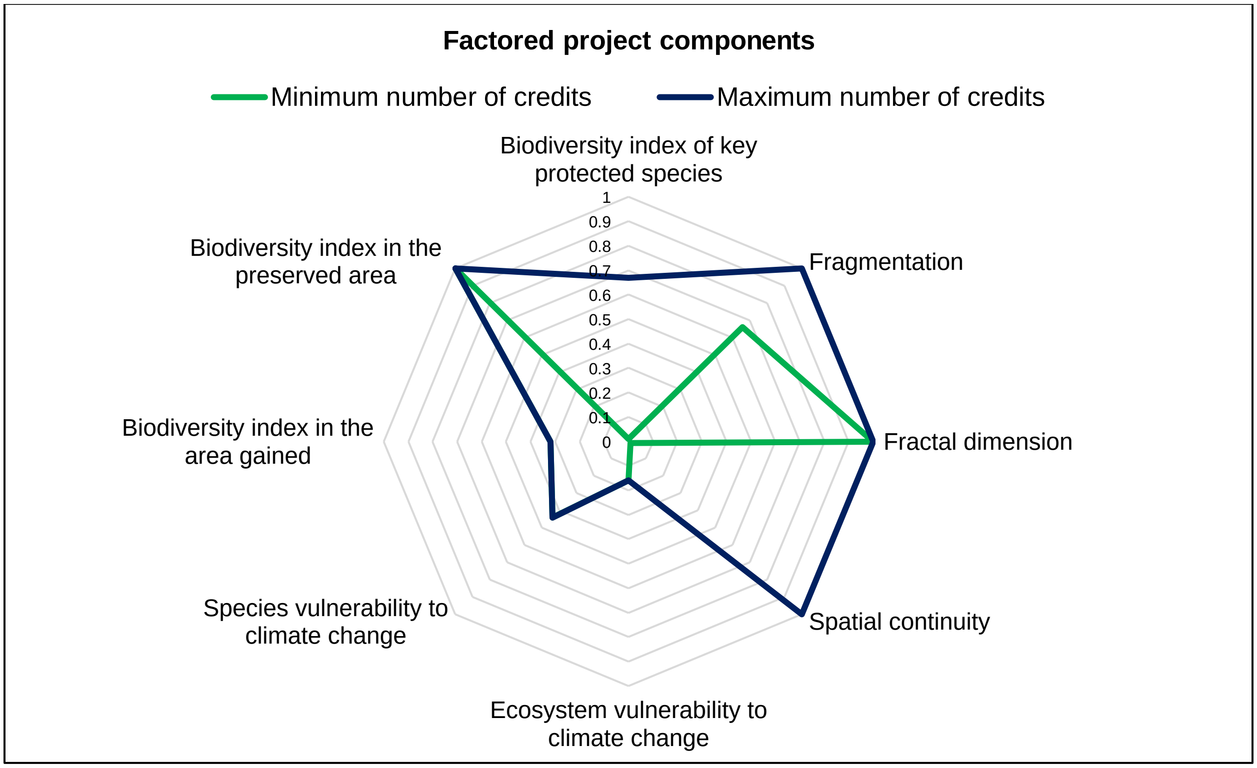


IMAGE 16. FACTORED PROJECT COMPONENTS IN TWO SCENARIOS

As established in section *III.1.2.* of the *Procedures document version 2.0*, **20%** of the credits generated by the project will be withdrawn for the buffer pool as a measure to guarantee the permanence of the project benefits (2,380 credits), resulting in a total of **9,520 biodiversity credits** to be issued according to the Contingency Table (Table 21).

TABLE 21. BIODIVERSITY CREDITS ISSUED ANNUALLY

Biodiversity credits issued annually												
Number of credits	**After project implementation**	**Y1**	**Y2**	**Y3**	**Y4**	**Y5**	**Y6**	**Y7**	**Y8**	**Y9**	**Y10**	**Total**
Percentage of VBBCs issued on each year (%)	32	10%	10%	10%	8%	5%	5%	5%	5%	5%	5%	**100%**
Number of VBBCs issued each year	3,046	952	952	952	762	476	476	476	476	476	476	9,520

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