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Structure of the Final Report

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10_CALL#5 – LandUnderPressure - Avoiding, mitigating and restoring land under pressure to combat desertification and increase resilience to climate change in the montado

Index

i. Detailed description

A1. Establishing a productivity baseline at the regional scale

The purpose of this task was to determine the productivity baseline at the regional scale in the areas occupied by the "montado" (cork oak and holm oak forests) and its trend of variation (increase, decrease, or stabilization) at a regional scale, over the past few years. The results allow the establishment of a Soil Degradation Baseline against which performance can be evaluated in the future to support the Land Degradation Neutrality (LDN) policy.

The results of the first, second and third sub-tasks were reported in the previous interim reports. The fourth sub-task is now completed, and all the results presented are available in an open repository and on the project website. The results presented in this report are from the period Jan-Apr 2024. The dissemination and discussion of the results with project stakeholders and collaborators will continue, in order to make the best use of them from a practical perspective as a tool for land management.

1.1 Geographical database of the montado areas

During the project's elapsed period, the first step involved delineating the areas occupied by cork oak and holm oak forests, which serve as the reference or "baseline" areas to be followed on a regional scale. The geographic database of montado area was completed and methodology described in the Interim report 2 and 3 and it is available in 1.1.Geographical database of the montado areas.

1.2 Maps of productivity baseline of Montado

This task was completed with the production of the maps with the productivity baseline (mean and standard deviation of evergreen productivity) of Cork oak and Holm oak in montado areas, during the period of 2000 to 2021 (previously presented in the results section and Annex I of the Interim report 3 and it is available in 1.2. Maps of productivity baseline of Montado).

1.3 Geographic database with productivity trends

The objective of this sub-task was to create a geographical database with productivity trends in montado. The mean slope of a linear model explaining the variability of evergreen productivity over the years was used to assess the productivity trend from 2000 to 2021. The decrease, stability or increasing trends of Holm oak and Cork oak productivity over time were mapped for two land uses, agroforestry systems and forests. These maps were presented previously in the Interim Report 4 and it is available in 1.3. Geographic database with productivity trends).

1.4 Model of the spatial heterogeneity of the montado productivity

The objective of this sub-task was to model productivity trends determined in the previous sub-task. This model includes as predictors environmental variables changing in space and time, such as climatic variables with 1km resolution, medium resolution edaphic variables (0.5-1km) and high-resolution topographic variables (25m). The model is now developed, and it is available in 1.4. Model of spatial heterogenity of the montado productivity

A2. Restoring degraded areas by managing grazing intensity

The objective of this task was to implement cost-effective restoration measures through grazing management, to promote the productivity of oak forests and the provision of ecosystem services in areas with different potential for oak natural regeneration and tree densities.

The implementation of the restoration pilot test took place at Herdade da Coitadinha (HC), in Barrancos. To this end, according to the planned schedule, outputs relating to sub-tasks 2.1 to 2.6 were completed and reported in the previous Interim Reports (1,2,3). All the results presented are available in an open repository and on the project website.

From January-April 2024, several working meetings took place with the FCUL team, as well as some field trips. In March 2024, four GPS collars for cattle were deployed at Herdade da Coitadinha: three using Sigfox signal and one using GSM signal. Additionally, a repeater was installed to extend the Sigfox signal in areas with low coverage. We chose these two different technologies because some parts of the property lack GSM coverage, and we aimed to test which signal provides more accurate results (see results section for more details). Monitoring of GPS collars performance and analysis of collected data will continue throughout this year (if possible, for a few years), to support grazing management measures and explore the usefulness of this tool in the context of the pilot restoration test implemented in the project, as well as its potential for application in other areas.

2.1 Map of the pilot project’s regeneration potential

A map was created for areas with high and low potential for natural regeneration in Herdade da Coitadinha in Barrancos. These maps use the Potential Solar Radiation (PSR), which represents the potential amount of solar radiation reaching a surface on the ground (in WH/m2). This map was previously documented in Figure 4 of the project´s Interim Report 1 and it is available at 2.1 Map of the pilot project’s regeneration potenttial).

2.2 Statistical model of tree density

Statistical modeling was performed last year using the Normalized Difference Vegetation Index (NDVI), and tree density based on the 2018 Tree Cover Density (TCD) at a local scale. The model was developed, and it is available at 2.2 Statistical model of tree density.

2.3 Tree density map of the pilot project

A map of holm oak density for Herdade da Coitadinha was generated based on the Tree Cover Density (TCD) product and the Normalized Difference Vegetation Index (NDVI) derived from satellite images. This map was previously documented in Figure 5 of the project's Interim Report 1 and it it available on2.3 Tree density map of the pilot project.

2.4 Methodological protocol to assess grazing intensity

Based on historical and current information regarding the number of livestock, cattle breed, and duration of grazing in various pasture areas within Herdade da Coitadinha (HC), as provided by HC collaborators, and supported by data obtained through fieldwork from April until June 2023, a protocol for assessing grazing intensity at HC has been developed (this was previously documented in **Annex II** of Interim Report 3, and an updated version is available 2.4.Methodological protocol for assessing grazing intensity).

2.5 Geographic database of areas subject to restoration

The selection of sites for the pilot restoration experiment at Herdade da Coitadinha was carried out and compiled into a geographic database. The selection of these sites was based on maps of potential natural regeneration, tree density, and grazing intensity, along with supplementary data such as slope, derived from the digital terrain model (DTM). A selection of plots for the experimental restoration area was made, with each plot covering ca. 1.5 hectares. There was a total of 12 treatments according to the criteria listed below, replicated 5 times, resulting in 60 plots covering 90 hectares. The selection criteria were as follows:
i) Sites with high and low potential for natural regeneration (based on the percentile of PSR <40% and PSR >60%, respectively).
ii) Sites with low and high tree density (percentile <40% and >60% of tree density, respectively).
iii) Sites without grazing and with low and high grazing intensity (no grazing, grazing intensity <0.62 and >0.62, respectively) (information presented in Interim Report 1; Figure 3).

The map with the location of the 60 plots was previously documented in Figure 6 and 7 of the project´s Interim Report 1 and Figure 2 of the Interim Report 2 and it is available on 2.5 Geographic database of areas subject to restoration).

In addition to the 1.5-hectare grazing exclusion plots described above, where grazing exclusion has been implemented by Herdade da Coitadinha for several years, small areas or subplots of 9 x 9 m (81 m^2) were also selected within areas that currently have grazing. These subplots were chosen to assess the short-term effects of grazing exclusion under different conditions of solar exposure (low and high PSR) and grazing intensity (low and high). The combination of these two criteria results in four different treatments, replicated five times, totalling 20 subplots. Fences were installed in each subplot to exclude grazing in March 2023, and adjacent control areas with a similar area were defined for the quantification of natural oak tree regeneration (as previously demonstrated in Figure 3 in the Interim Report 2). The fieldwork to monitor natural regeneration inside these plots were performed in April 2024 (Figure 1). We have counted and measured the heigh of all the holm oak natural regeneration in control and fenced plots and later compared them to see the effect of fences implementation on tree regeneration (for further details see results section). Since the effect of this measure on the provision of other ecosystem services (e.g. pollinators, herbaceous diversity...) can be only seen in the long-term, we intend to keep monitoring it for longer time frames (at least for 2 years), to have more robust results.

Figure 1. Details of the field work to monitor natural regeneration inside the 9x9m fences at Herdade da Coitadinha.

2.6 Geographic database of grazing intensity

A geographic database was created to document grazing intensity at Herdade da Coitadinha. Using historical and current information about the number of cattle, cattle breed, and the duration of their stay in each grazing area at Herdade da Coitadinha, provided by HC collaborators, grazing intensity was calculated for the entire property. This map was previously documented in Figure 8 of the project´s Interim Report 1 and it is available 2.6 Geographic database of grazing intensit).

A3. Quantify Ecosystem Services (ES) in restoration and in drought scenarios

The objective of Activity A3 was to assess the impact of restoration measures and experimental drought simulation on the provision of Ecosystem Services (ES) related to Regulation, Provisioning, and Cultural services. This activity was conducted at 40 of the 60 sampling sites subject to restoration (Activity 2) representing 8 main treatments as follow: i) with high and low natural regeneration potential, based on Potential Solar Radiation (PSR <40% and PSR>60% percentile, respectively); ii) with low and high tree cover density (percentile <40% and >60%, respectively); iii) excluded from grazing, and with high grazing intensity (no grazing and with grazing intensity >0.62, respectively). The impact of drought simulations was assessed in 5 replicates of 100m^2 plots where experiments with rainout shelters (rain exclusion devices) were installed in September 2022. These experiments are carried out in synergy with the national research project RENEWAL (PTDC/ASP-SIL/7743/2020) in areas without grazing at Herdade da Coitadinha.

From March to December 2023, fieldwork was carried out to quantify the following ES: i) Provisioning: food for livestock (herbaceous biomass); ii) Regulation: forest life cycle (natural regeneration and demography of oak trees), plant abundance and diversity (shrub and herbaceous), abundance and diversity of pollinator insects and birds, seed dispersers, or pest controllers, nutrient cycling (leaf litter decomposition and metagenomics of decomposers), carbon sequestration by vegetation, and microclimatic regulation; iii) Cultural: surveys to assess tourists' appreciation (current or potential) of landscapes similar to those resulting from the pilot restoration experiment at HC, as well as the economic value they are willing to pay to maintain these landscapes. During these period (March- December 2023), the main fieldwork activities related to the estimation of ES have been completed, as further described. Data processing, entry and statistical analyses have been now completed. Since the results of these task are not yet publish in scientific articles, we stored it in a google drive repository and made it available on the website upon request. The dissemination and discussion of the results with project stakeholders and collaborators, as well as through scientific publications, will continue, in order to make the best use of them from a practical perspective as a tool for land management.

3.1 Database with herbaceous biomass

The fieldwork related to this task began in April 2023 and ended in June 2023 (as presented in Figure 5 of the Interim Report 2). The lab work and data entry related to this task were completed in December 2023 and the database is available in 3.1. database biomass of herbaceous.

3.2 Database with acorn biomass

The fieldwork to quantify acorn production was done in November 2023 (as presented in Figure 3 of the Interim Report 4). Data entry related to this task were completed in December 2023 and the database of acorn biomass is available in 3.2. database of biomass of acorns.

3.3 Oak demographic database

The objective of this subtask was to characterize the demographics of oak trees through the quantification of individuals in various stages of development (seedlings, young plants, and trees). The field work to quantify oak demography was fully completed in November 2023 (as presented in Figure 4 of the Interim Report 4). Data entry related to this task were completed in December 2023 and the database with the inventory of seedlings, young and adult trees was added in 3.3. Database of oak demography.

3.4 Database with plant abundance and diversity

The fieldwork related to this task began in April and it ended in June 2023 (Figure 1 and as presented in Fig. 5 of the Interim Report 2). The species identification and data entry were completed in December 2023. The abundance and diversity of plants are now calculated and statistical analysis are performed. The database with all these information was added in 3.4.database abundance and diversity of plants.

3.5 Database with bird abundance and diversity

The fieldwork for this task began in May 2023 and it ended in June 2023 (as reported in the Interim Report 3 and 4). Data entry and processing were completed in December 2023. The abundance and diversity of birds classified according to different functional groups of birds (pollinators, dispersers and pest controllers) are now calculated and statistical analysis were performed. The database with all these information was added in 3.5.database abundance and diversity of birds.

3.6 Database with carbon sequestration

This subtask related to the estimation of carbon sequestration by the vegetation above and belowground was completed in December 2023 (as reported in the Interim Report 4), and the final database is now presented in 3.6. database with carbon sequestration .

3.7 Microclimatic database

This subtask was completed in December 2023, as reported in the Interim Report 4. The microclimatic regulation assessment was done through the evaluation of tree shading based on the Leaf Area Index (LAI) in each plot which includes trees and shrubs. The final database is presented in 3.7.microclimatic database.

3.8 Database with questionnaire results

During the project, an opportunity arose to integrate a Master's thesis in Environment and Resource Management by ERASMUS+ student Magdalena Lesch from Vrije Universiteit Amsterdam into the context of this subtask. The work involved the creation and analysis of results from an online/in-situ survey (n = 37) and it was already completed and reported in the Report 3 and 4. The survey was made available online and the thesis containing the database with questionnaire results is available at 3.8 database with questionnaire results (Thesis Magdalena).

3.9 Statistical model on the impact of restoration measures on ES delivery

This subtask, which depended on the results obtained in the previous subtasks (3.1-3.7), is now completed. Generalized linear models (GLMs) and Generalized Additive Models (GAM) were used to explain the effect of Potential Solar radiation, Tree density cover and Grazing intensity on each of the ecosystem services indicators. The results related to this task are available in 3.9. Statistical model on the impact of restoration measures on ES delivery.

3.10 Report describing the impact of restoration measures on the delivery of ES

This subtask, which depended on the results obtained in the previous subtasks (3.1-3.9), is now completed. The results related to this task are available in 3.10 Report describing the impact of restoration measures on the delivery of ES .

A4. Assessment of soil ES in restoration areas

Activity A4 aimed to quantify regulating services provided by the soil in the pilot restoration areas at Herdade da Coitadinha. It involved quantifying climate regulation, carbon sequestration, nutrient cycling, decomposition, and erosion control services provided by soil. Planning for these activities was carried out during the project, with fieldwork commencing in May 2023 and most of it already finished in December 2023, following the project's timeline. Within the scope of this activity, several working meetings and exchanges of relevant information took place with partners from Instituto Politécnico de Bragança (IPB), responsible for subtasks 4.1, 4.2, and 4.6. Data processing, entry and statistical analyses have been now completed. Since the results of these task are not yet publish in scientific articles, we stored it in a google drive repository and made it available on the website upon request. The dissemination and discussion of the results with project stakeholders and collaborators, as well as through scientific publications, will continue, in order to make the best use of them from a practical perspective as a tool for land management.

4.1 Water balance database

The team from IPB has finalized this task. The measurements in the field were finalized in November 2023, and the methodology for evaluating soil permeability and details of the field work were already presented in Figure 5a and 5b of the Interim report 4. Various methodological aspects for calculating soil water balance for Herdade da Coitadinha are presented in greater detail in the annex to this report.

After defining the water balance in the whole area of Herdade da Coitadinha, the water balance parameters (water storage (A), change in storage (dA), actual evapotranspiration (ETR), soil water deficit (D) and soil water surplus (S)) were extracted and a final database containing these data per plot (40 plots) is available in 4.1 Water balance database.

4.2 Database of soil organic matter and carbon content

This subtask, whose main objective was the assessment of soil carbon sequestration as a carbon sink and in the regulation of greenhouse gases, is now finished. We have collected 40 composed soil samples (containing 5 subsamples) from April until June 2023 (as presented in Figure 5 of the Interim Report 2). These samples were sent to the laboratory for chemical analysis of soil organic matter and carbon content in February 2024 and are available in 4.2 Database of soil organic matter and carbon content.

4.3 Soil nutrient content database

This subtask is now finished. We have collected 40 composed soil samples (containing 5 subsamples) from April until June 2023 (as presented in Figure 5 of the Interim Report 2). These samples were sent to the laboratory for nutrient cycling assessment through chemical analysis of soil nutrients (e.g. texture, pH, nitrogen) in February 2024 and are available in 4.3 Soil nutrient content database .

4.4 Decomposition rate database

The Tea Bag Method (Keuskamp et al. 2013; Djukic et al. 2018) and metagenomic analyses are used to assess soil biodiversity and its role in organic matter decomposition and maintenance of soil carbon stocks. Teabags were buried in May and June 2023 and unearthed in the November 2023 (previously presented in interim Report 4, Figure 6). Laboratory work for processing teabags were done December 2023 and data entry is now completed. The database is available at 4.4.database decomposition rate.

4.5 Database on the diversity of decomposer organisms

This subtask is currently finished. To assess the biodiversity of decomposers, composite soil samples (encompassing the 40 plots) were collected to characterize the 8 restoration treatments in May and June 2023. Soil DNA was extracted, and samples were sent for metagenomic analyses. The database with the abundance of microorganism in the 8 restoration treatments are available in 4.5 Database on the diversity of decomposer organisms.

4.6 Soil loss database

Soil losses generated by erosion on the ground are being measured using erosion measuring devices at a few key points in the Herdade da Coitadinha. The erosion devices were implemented in November 2023 as it was previously reported on the Figure 7,8,9 and 10 of the Interin report 4. However, a week after the erosion plots were installed, the cattle grazing there completely destroyed them (Figures 2 and 3). To overcome this unfortunate situation, the team returned to

Herdade da Coitadinha in March 2024 to rebuild the erosion plots and reinforce protection around them with iron cages (Figures 4 and 5). Since erosion process takes time, the IPB team intends to keep monitoring the erosion devices beyond the timeframe of the project to have more robust results.

Complementarily, in order to get a global view of spatial distribution of soil loss in Herdade da Coitadinha, an estimate was made based on the soil analyses previously carried out and described in the Interin report 4. Three measured parameters have a major influence on estimating this degradation process in the soil: vegetation cover, soil porosity and slope, and the results were presented at Table 1 Interim report 4. Further methodological details for the estimation of soil loss for Herdade da Coitadinha are presented in the Annex to this report.

Figure 2. Erosion measuring device partially destroyed.

Figure 3. Erosion measuring device completely destroyed.

Figure 4. Erosion measuring device restored and isolated from animals.

Figura 5. Erosion measuring protective grid and its opening for collecting material.

The team from IPB has finalized this task. The full date base containing the extracted values of potential and actual erosion per plot (40 plots) is now available at 4.6 Soil loss database.

4.7 Statistical model

This subtask depended on the results obtained in the previous tasks (4.1-4.6) and is now completed. Generalized linear models (GLMs) were used to explain the effect of Potencial Solar Radiation, tree density cover and grazing intensity on each of the ecosystem services indicators. The results related to this task are available in 4.7. Statistical model explaining the impact of restoration measures in soil ES delivery.

A5. Co-building and disseminating the best solutions to restore ES

The objective of Activity A5 was the co-construction and dissemination of the most sustainable restoration solutions to ensure the maintenance and, if possible, enhancement of ecosystem services in the montado.

5.1 Report with local restoration measures

Following the activities carried out in Task 2, various restoration solutions were discussed and outlined to promote the natural regeneration of cork oak and holm oak and enhance the ecosystem services of the montado. These solutions were discussed with local stakeholders, including the collaborators of Herdade da Coitadinha. The report of local restoration measures was previously presented in the interim report 3 and can be found in the open repository and on the website of the project.

5.2 Regional restoration measures report

This subtask was based on the Workshop for regional actors that took place on March 19, 2024 together with the final Seminar of the project, at the Pavilhão Multiusos de Mértola. The workshop consisted of a participatory session to discuss the restoration measures implemented in the project and also others proposed by the participants, aimed to collect contributions by actively involving participants, allowing everyone to express their opinion on the topic. This subtask is now completed, and the results are available at is now completed, and it is available on the website (5.2. Regional restoration measures report).

5.3 Workshop for local actors

The workshop with local stakeholders was conducted in 2022 and it was described in the interim report 1 and 2.

5.4 Workshop for regional actors

The workshop for regional stakeholders took place together with the final seminar of the project LandUnderPressure, on the 19th March 2024, in collaboration with ADPM (also EEA Project + Solo +Vida), at the Pavilhão Multiusos de Mértola (Figure 6). Doing a joint meeting combining two EEA projects in a single event was considered an added value, since the projects address closely related themes relevant for the same geographical area, complementing each other and also to increase the mobilization of local participants and the critical mass present at the event. Furthermore, the involvement of various actors on the part of both projects increases the chances of attendance and acceptance of invitations. Thus, farmers participating in the +Solo +Vida project were invited, as well as other farmers from the region, and also representatives of relevant entities such as ICNF, and other scientific research institutions (27 participants).

The event was divided into two parts, the first one was dedicated to LandUnderPressure and the second to +Solo+Vida Project (EEA Grants project coordinated by ADPM). First, there was a presentation about the main results achieved in the project, including the monitoring of productivity trends across space and over time (ca. 20 years) on a regional scale, and also the effect of the restoration measures implemented in the pilot test on multiple ecosystem services. After this presentation, a participatory approach was facilitated to encourage knowledge exchange related to the restoration solutions implemented in the project and utilized by the participants. During the dynamic discussion, the Slido mobile phone application (slido.com) was used so that everyone could answer the questions anonymously if they felt inhibited. The answers were then presented to all and discussed, given the opportunity to intervene to anyone who wanted to respond orally and/or debate the answers given by everyone. For further details see 5.2. Regional restoration measures report.

Figure 6. Photos of the regional workshop with stakeholders, held together with the Final seminar of the project LandUnderPressure, 19th march, 2024, Mértola.

Our partner from one of the donor countries, Kristín Svavarsdóttir, from the (previously called) Soil Conservation Service of Iceland, now called Land and Forest Iceland, was also invited to participate in the workshop. Kristín brought her expertise in soil conservation and ecosystem restoration in Iceland, which she shared with the project's members during meetings, a field visit to the pilot project site (Figure 7), and an open presentation at FCUL (https://ce3c.ciencias.ulisboa.pt/outreach/press&events/ver.php?id=1563).

Figure 7. Details of the field work visit at Herdade da Coitadinha with Alice Nunes, project coordinator and Kristín Svavarsdóttir, partner from Iceland.

5.5 Development and dissemination of an electronic book

This subtask depended on the results obtained in the previous tasks (A3,4), and also from the 5.3 and 5.4 subtask. The ebook content is now completed, and the final design is nearly finished and it is available in the project website and will be sent to the stakeholders that participated in the workshop for regional and local actors, and also disseminated to the public. The ebook focuses on grazing management as a tool to restore ecosystem services and promote the resilience of montado to climate change. It is bilingual and incorporates infographics to convey the message in a clear and straightforward manner. This approach aims to empower decision-makers, land managers and farmers to make well-informed choices regarding the implementation of restoration strategies in their respective management areas.

5.6 Development and dissemination of informative graphics

This subtask depended on the results of the previous tasks (A3,4), and it is now completed. Infographics were developed and disseminated throughout the ebook and website and in the future, in other publications related to the topic.

5.7 Development and dissemination of an animated video

This subtask depended on the results of the previous tasks (A3,4), and also from the 5.3 and 5.4 subtask, and it is now completed (Figure 8). The LengaLenga company was hired to develop two videos, a long one focusing in explaining the whole context of the project and a short version (<2 min) giving a brief introduction of the project. The videos were disseminated in the cE3c Instagram (https://www.instagram.com/reel/C7hISfBMjjx/?igsh=cThyaGR6M216ZzZn), E-changes YouTube channel (https://youtu.be/Q-N3g6z7hWk , https://youtu.be/MH3sOcyHhcM), cE3c twitter (https://x.com/ce3cresearch/status/1795499752630407536?s=46&t=VlpsEED7M5t3vCMpzZSrWQ) and also on the website of the project.https://youtu.be/MH3sOcyHhcM), cE3c twitter (https://x.com/ce3cresearch/status/1795499752630407536?s=46&t=VlpsEED7M5t3vCMpzZSrWQ) and also on the website of the project.

Figure 8. Making off of the video at Herdade da Coitadinha, March 2024.

In addition to the described activities, this Final Report has been produced as part of the project's management actions. A summary of the activities performed is presented in Table 1.

Table 1. Summary of activities carried out during the project.

ID	Name of Activity	Indicator	Situation	Observations/Extension justification
1	Establishing a productivity baseline at the regional scale	1.1. Geographical Information system database of the montado areas	Completed	
1	Establishing a productivity baseline at the regional scale	1.2. Geographical Information system database with mapped baseline productivity	Completed	

ID	Name of Activity	Indicator	Situation	Observations/Extension justification
1	Establishing a productivity baseline at the regional scale	1.3. Geographical Information system database with productivity trend classification	Completed	
1	Establishing a productivity baseline at the regional scale	1.4. Statistical multivariate model explaining the productivity's spatial heterogeneity	Completed	
2	Restoring degraded areas by managing grazing intensity	2.1. Map of the potential natural regeneration in the pilot project	Completed	
2	Restoring degraded areas by managing grazing intensity	2.2. Statistical model for tree density	Completed	
2	Restoring degraded areas by managing grazing intensity	2.3. Map of tree density of the pilot project	Completed	
2	Restoring degraded areas by managing grazing intensity	2.4. Methodological protocol for the evaluation of grazing intensity	Completed	
2	Restoring degraded areas by managing grazing intensity	2.5. Geographic database of areas subject to restoration	Completed	
2	Restoring degraded areas by managing grazing intensity	2.6. Geographic database of grazing intensity	Completed	
3	Quantify Ecosystem Services (ES) in restoration and in drought scenarios	3.1. Database of herbaceous biomass	Completed	
3	Quantify Ecosystem Services (ES) in restoration and in drought scenarios	3.2. Database of acorn biomass	Completed	
3	Quantify Ecosystem Services (ES) in restoration and in drought scenarios	3.3. Database with the demography of oaks	Completed	
3	Quantify Ecosystem Services (ES) in restoration and in drought scenarios	3.4. Database of abundance. and div. of plants	Completed	
3	Quantify Ecosystem Services (ES) in restoration and in drought scenarios	3.5. Database of bird's abundance and diversity in restoration areas	Completed	
3	Quantify Ecosystem Services (ES) in restoration and in drought scenarios	3.6. Database of carbon sequestration by vegetation	Completed	
3	Quantify Ecosystem Services (ES) in restoration and in drought scenarios	3.7. Database of microclimatic data	Completed	
3	Quantify Ecosystem Services (ES) in restoration and in drought scenarios	3.8. Database with questionnaire results	Completed	

ID	Name of Activity	Indicator	Situation	Observations/Extension justification
3	Quantify Ecosystem Services (ES) in restoration and in drought scenarios	3.9. Statistical models explaining the impact of restoration measures in ES delivery	Completed	
3	Quantify Ecosystem Services (ES) in restoration and in drought scenarios	3.10. Report on the impact of restoration measures on the delivery of several ecosystem services and their trade-offs	Completed	
4	Assessment of soil ES in restoration areas	4.1. Database of soil water balance	Completed	
4	Assessment of soil ES in restoration areas	4.2. Database of soil organic matter and organic carbon	Completed	
4	Assessment of soil ES in restoration areas	4.3. Database of soil nutrients content	Completed	
4	Assessment of soil ES in restoration areas	4.4. Database of litter decomposition rate	Completed	
4	Assessment of soil ES in restoration areas	4.5. Database on the diversity of decomposer organisms	Completed	
4	Assessment of soil ES in restoration areas	4.6. Database of soil loss	Completed	
4	Assessment of soil ES in restoration areas	4.7. Statistical model	Completed	
5	Co-building and disseminating the best solutions to restore ES	5.1. Report on restoration measures at local scale	Completed	
5	Co-building and disseminating the best solutions to restore ES	5.2. Report on restoration measures at regional scale	Completed	
5	Co-building and disseminating the best solutions to restore ES	5.3. Workshop for local stakeholders	Completed	
5	Co-building and disseminating the best solutions to restore ES	5.4. Workshop for regional stakeholders	Completed	
5	Co-building and disseminating the best solutions to restore ES	5.5. Development and dissemination of an electronic book	Completed	
5	Co-building and disseminating the best solutions to restore ES	5.6. Development and dissemination of informative graphics	Completed	The infographics developed integrate the ebook produced
5	Co-building and disseminating the best solutions to restore ES	5.7. Development and dissemination of an animated video	Completed	
Man.		Final Report (5)	Completed	

ii. Results achieved

During the period from January to April 2024, and throughout the entire project, the planned activities in the LandUnderPressure project generally proceeded according to the planned schedule, achieving all the set goals. Below are the main results of each activity.

A1. Establishing a productivity baseline at the regional scale

Within Activity A1, three sub-tasks had already been completed and reported in the Interim Report 4. The following outputs were delivered: i) a geographic database of montado areas, which includes priority areas B; ii) maps of the productivity baseline of Montado areas from 2000 to 2021 and iii) maps for the evergreen productivity trends of Montado areas from 2000 to 2021. Here, we present results for modelling the spatial heterogeneity of the montado productivity. The productivity of perennial and annual vegetation was modeled using a generalized linear model. The factors that influence the mean productivity were evaluated using the variables' coefficients present in the best 15 models.

The mean productivity was explained by climatic, topographic and edaphic factors (Figure 9). Climatic factors associated with water availability such as the aridity index (the ratio between average annual precipitation and potential evapotranspiration), increase perennial and annual vegetation productivity. Edaphic factors associated with soil physical properties, such as higher soil compactness, are negatively associated with productivity. Topographic factors associated with lower and plane areas were related with higher productivity of perennial vegetation and lower productivity of annual vegetation.

Overall, the mean productivity of 2000-2021 is strongly associated with long-term precipitation. The productivity of perennial vegetation suggests a threshold between 600 and 700 mm of annual precipitation, below which it limits productivity and after which it reaches a plateau, while the productivity of annual vegetation shows an increasing linear trend with increasing annual precipitation (Figure 10).

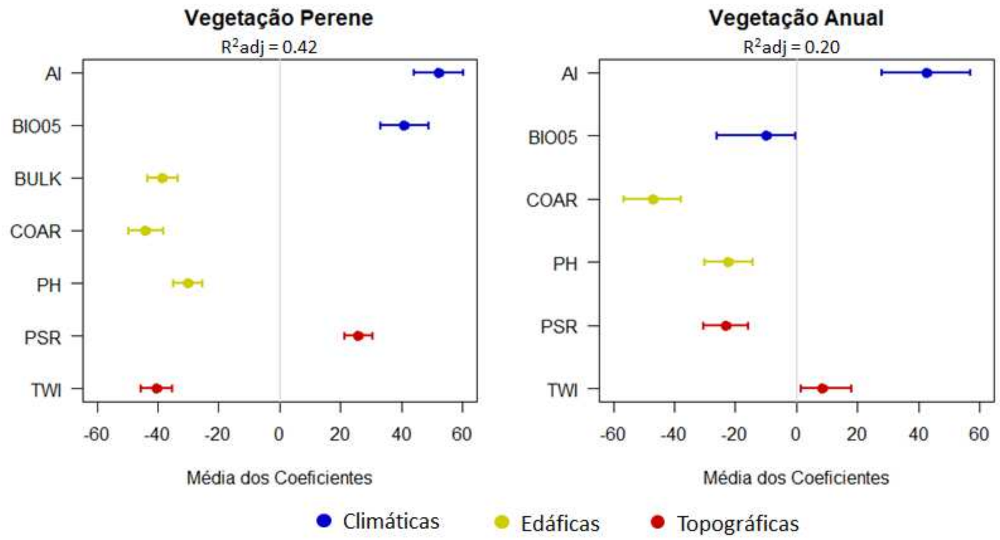

Figure 9. Standardized model-averaged coefficients of predictor variables of perennial and annual vegetation mean productivity (2000-2021). Coefficients were averaged across the top 15 models, means and 95% confidence intervals are shown. Different colors represent the different types of environmental variables. AI - Aridity Index, BIO05 - mean daily maximum air temperature of the warmest month, BULK - Bulk Density, COAR - Coarse soil, PH - Soil pH, PSR - Potential Solar Radiation, TWI - Topographic Wetness Index.

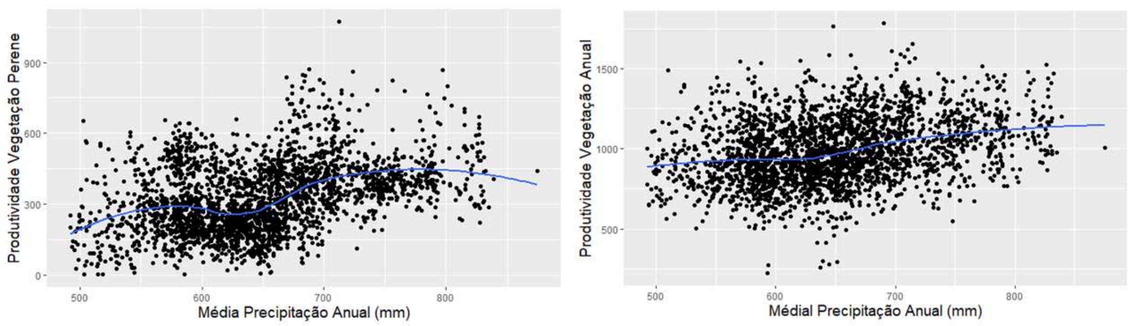

Figure 10. Relation of mean productivity from 2000-2021 of perennial and annual vegetation with mean annual precipitation (mm). N = 2650, line represents a loess smoothing curve.

A2. Restoring degraded areas by managing grazing intensity

The implementation of the pilot restoration trial at Herdade da Coitadinha (HC) was completed, including the installation of short-term exclusion fences and cactus-type protectors for natural regeneration in grazed areas (as presented in Fig. 4 of the Interim Report 2). The outputs related to subtasks 2.1 to 2.6 were produced according to the planned schedule (as presented in Interim Report 1,2 and 3).

A protocol for assessing grazing intensity at Herdade da Coitadinha (A2.4) was developed (Annex II – Interim Report 3 and [2.4 Methodological protocol for assessing grazing intensity](#)).

The purchase of GPS collars for cattle was completed, and field implementation occurred in March 2024. We installed four GPS-tracked collars, from Digitanimal, on the leaders of the cattle herd at Herdade da Coitadinha. The criteria for choosing the collar model were based on the respective cost and the technology used, with 3 collars selected with transmission via the SigFox network (with the installation of a repeater in the field) and 1 with transmission via the GSM network, to compare their effectiveness in the context of Herdade da Coitadinha. These devices allow us to monitor and map cattle movements across the landscape with high spatial resolution. It thus provides information for more precise livestock management and also for better planning of restoration actions in montado (Figure 11).

The preliminary data collected to date reveals good coverage and will be used to analyze livestock distribution and grazing pressure with high spatial resolution at the landscape scale. This information is very useful to support grazing management to promote montado resilience, for instance, allowing to propose differentiated restoration solutions for areas with greater or lesser grazing pressure (e.g., installing individual protectors or creating grazing exclusion areas). At the same time, through collaboration with researchers in the field of computer engineering, the development of a collar prototype is underway to overcome some of the technical limitations identified.

Figure 11. Trajectory of the 4 monitored caws on April 9th 2024 through the GPS collars at Herdade da Coitadinha, Barrancos, Portugal.

Additionally, small grazing exclusion areas were created within grazed areas, to assess their effect on promoting key ecosystem services, under contrasting solar exposure (low and high Potential Solar Radiation - PSR) and grazing intensity (low and high) conditions (Figure 12). For that, 20 subplots of 9 x 9 m (81 m^2) were selected and fenced, to exclude them from grazing, in March

2023, and adjacent control areas were defined for the quantification of natural oak tree regeneration.

Field work for monitoring oak regeneration started in April 2024. Preliminary results show that oak natural regeneration is significantly higher in the excluded areas one year after its implementation, especially in areas with lower solar exposure (Figure 13), showing the effectiveness of this measure. Regeneration after the implementation of exclusion is higher than that seen in large areas excluded more than 5 years ago, suggesting a possible stabilization of regeneration over time, probably due to the progressive increase in shrub and tree cover in these areas, as observed in previous studies (Kobel et al., 2021). The impact of this measure on other ecosystem services requires more time to detect effects, so its assessment can only be done in the medium/long term.

Figure 12. Small grazing exclusion areas in 9 x 9 m plots (20 plots in total) and adjacent control areas with grazing, implemented in March 2023 at Herdade da Coitadinha, Barrancos, Portugal.

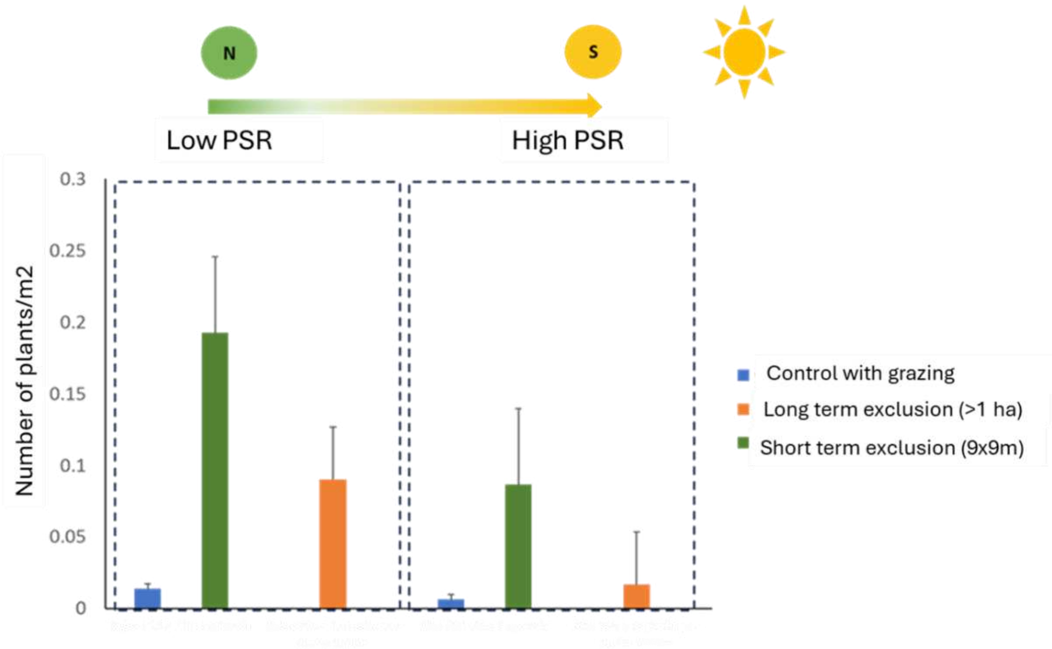

Figure 13. Density of holm oak seedlings (<30 cm in height) in small exclusion areas (81 m2) implemented one year ago (green), adjacent control areas with grazing (blue) and large exclusion areas (> 1 ha) implemented more than 5 years ago (orange), at Herdade da Coitadinha, Barrancos, Portugal.

A3. Quantify Ecosystem Services (ES) in restoration and in drought scenarios

Most of the fieldwork involved in sub-tasks of activity A3 have finished between April-November 2023, to create databases for herbaceous biomass, plant abundance and diversity, bird and insect pollinators and pest predators, acorn biomass, demography of oak, carbon sequestration, microclimatic data, and questionnaire results. The lab work, data processing and entry were completed in December 2023. Since the results of these task are not yet publish in scientific articles, we stored it in a google drive repository and made it available on the website upon request.

The results related to the subtasks 3.9 and 3.10, involving statistical models that explain the impact of restoration measures on ecosystem services delivery and the subsequent report can be detailed assed in the 3.10 Report describing the impact of restoration measures on the delivery of ES. In summary, we conclude tree cover density generally has the most significant impact on ecosystem services (Table 2). Potential solar exposure and grazing pressure also have significant effects. Areas with higher tree canopy cover enhance microclimate regulation, carbon sequestration, acorn production, natural regeneration, and bird diversity, mainly pollinating birds. In contrast, areas with lower tree canopy cover exhibit higher herbaceous biomass (Table 2). Areas with lower solar exposure (north-facing) have better oak regeneration, higher herbaceous species diversity, and improved microclimate regulation due to higher tree cover compared to areas with higher solar exposure (Table 2). Excluding grazing increases shrub diversity and abundance, improves microclimate regulation, and enhances oak regeneration. Large grazing exclusion areas with low solar exposure (north-facing) show increased shrub density and decreased herbaceous biomass due to competitive pressure. Conversely, areas with high grazing pressure, browsing, and high solar exposure (south-facing) show declines in both shrub abundance and herbaceous biomass.

Table 2. Impact of tree cover density, solar exposure, grazing intensity, and the interaction between solar exposure and grazing intensity on the provision of several ecosystem services.

Classification	Ecosystem services	Indicator	Tree cover	Solar exposure	Grazing intensity	Solar exp.*Grazing intensity
Provisioning	Food for cattle	**Herbaceous biomass**	-	ns	ns	-
		Acorn biomass	+	ns	ns	ns
Regulating	Forest regeneration	**Natural regeneration**	+	-	-	ns
	Biodiversity	**Diversity of herbaceous**	ns	-	ns	ns
		Abundance of shrubs	ns	ns	-	+
		Diversity of shrubs	ns	ns	-	ns
		Diversity of birds	+		ns	
		Richness of bird pollinators	+		ns	
	Microclimate regulation	**Leaf Area Index**	+	-	-	ns
	Carbon stock by the vegetation	**Aboveground carbon**	+	ns	ns	ns
		Belowground carbon	+	ns	ns	ns

A4. Assessment of soil ES in restoration areas

The subtasks of activity A4 for creating databases related to soil water balance, organic matter and carbon content, nutrient levels, litter decomposition rates, diversity of decomposing organisms and soil loss rate are now completed. Since the results of these task are not yet publish in scientific articles, we stored it in a google drive repository and made it available on the website upon request.

Soil degradation and soil loss processes are largely influenced by soil porosity, which can vary with grazing pressure, but also with vegetation cover and topography (e.g. slope). Porosity indicates the degree of soil compaction, which in turn can lead to changes in the physical properties of the soil, increasing its susceptibility to erosion and making it more likely to be removed by water or wind. Vegetation cover mitigates the impact of raindrops that fall to the ground and helps to retain and disperse the speed of surface runoff. The slope is directly linked to the speed at which water flows over the land; the steeper the slope, the more intense and rapid the surface runoff tends to be (these results were presented in Table 1 Interim report 4).

The results of the assessment of soil-related ecosystem services in areas under restoration can be seen in Table 3. Laboratory analyses revealed a higher carbon/nitrogen ratio in areas excluded from grazing. This higher ratio is often associated with more resistant organic matter, such as woody materials (e.g. more shrubs and trees than herbaceous), which decompose slowly and contribute to the long-term buildup of soil organic matter. It also indicates a higher percentage of carbon compared to nitrogen in the soil at the moment, which can enhance carbon sequestration capacity and positively impact the nutrient cycle in these exclusion areas. Grazing areas had a lower climate regulation capacity associated with the soil, characterized by reduced water storage capacity, greater soil water deficit due to decreased vegetation cover compared to excluded areas. Grazing also led to lower soil porosity (greater compaction), resulting in more bare and unprotected soil and higher erosion, when compared to soil in excluded areas. Additionally, excluded areas had more permeable soils than the soils trampled by cattle (Table 4).

Furthermore, solar exposure had a negative influence on the percentage of organic matter, carbon, and nitrogen in the soil. Higher solar exposure leads to increased soil temperatures, which result in reduced plant growth and organic matter input, enhanced volatilization of nitrogen, greater soil erosion due to less vegetation cover, and lower soil moisture. All these factors contribute to decreased carbon and nitrogen levels in the soil, consequently affecting nutrient cycles in more exposed areas. We did not observe a direct significant effect of tree cover, potential solar radiation, or grazing intensity on the decomposition rate.

Table 3. Impact of tree cover density, solar exposure, grazing intensity on the provision of several soil ecosystem services. Significant Generalized Linear Models * p<0.05 ** p<0.01 ***p<0.00 (T-test).

Ecossystem Service	Predictor	Intercept	Tree cover	Solar exposure	Grazing intensity	R^2adj
Water Balance	Soil Water Storage	68.745 (1.745) ***	ns	ns	-7.293 (1.768) ***	0.291
	Evapotranspiration	425.502 (1.729) ***	ns	ns	-7.253 (1.751) ***	0.293
	Soil Water Deficit	431.253 (1.728) ***	ns	ns	7.247 (1.750) ***	0.293
	Surplus or Excess	137.977 (1.728) ***	ns	ns	7.244 (1.750) ***	0.293
Nutrient Cycling	Organic matter	5.525 (0.214) ***	ns	-0.789 (0.216) ***	ns	0.249
	Total Carbon	3.226 (0.127) ***	ns	-0.443 (0.129) **	ns	0.227
	Organic Carbon	3.205 (0.124) ***	ns	-0.456 (0.126) ***	ns	0.248
	Total Nitrogen	0.258 (0.010) ***	ns	-0.03 (0.010) **	ns	0.167
	Carbon Nitrogen Ratio	12.695 (0.213) ***	ns	-0.455 (0.216) *	-0.524 (0.216) *	0.240
Decomposition Rate	Tea Bag Index	ns				
Soil Retention	Bare Soil	20.409 (1.887) ***	ns	ns	12.131 (1.911) ***	0.508
	Potential Erosion	3.348 (0.117) ***	ns	ns	-0.411 (0.119) **	0.263
	Actual Erosion	ns				

Table 4. Results of the soil analysis in the permeameter, containing permeability (k), field capacity (CC), porosity (P) and microporosity (MicroP). Grazing exclusion points (ending in E) and grazed points (ending in A). The k classes show that the vast majority of the points classified as permeable (fast or very fast) are in the exclusion zones.

Point	K inicial (cm/h)	Ki Class	K final (cm/h)	Kf Class	CC (%)	P (%)	MicroP (%)
BAA1	49,00	Very fast	35,36	Very fast	0,27	0,45	0,41
BAA1	35,18	Very fast	24,13	Fast	0,28	0,45	0,41
BAA1	23,17	Fast	27,63	Very fast	0,32	0,49	0,46
BAA1	0,69	Moderately slow	0,36	Slow	0,34	0,49	0,46
BAA3	179,28	Very fast	160,44	Very fast	0,60	0,57	0,54
BAA3	0,04	Very slow	0,01	Very slow	0,36	0,51	0,47
BAA3	17,22	Fast	10,65	Moderately fast	0,28	0,45	0,41
BAA3	0,00	Very slow	0,00	Very slow	0,36	0,49	0,45
BAE1	70,30	Very fast	57,19	Very fast	0,28	0,45	0,41
BAE1	0,17	Slow	8,95	Moderately fast	0,41	0,49	0,45
BAE1	35,21	Very fast	62,73	Very fast	0,33	0,48	0,45
BAE1	375,00	Very fast	362,40	Very fast	0,35	0,52	0,48
BBA4	0,46	Slow	0,49	Slow	0,34	0,50	0,47
BBA4	0,19	Slow	0,08	Very slow	0,41	0,52	0,49
BBA4	13,71	Fast	15,52	Fast	0,32	0,48	0,44
BBA4	0,06	Very slow	0,09	Very slow	0,45	0,50	0,47
BBA5	298,01	Very fast	579,43	Very slow	0,36	0,52	0,48
BBA5	6,83	Moderately fast	5,48	Moderate	0,26	0,44	0,40
BBA5	0,11	Very slow	0,07	Very slow	0,35	0,49	0,46
BBA5	7,81	Moderately fast	7,27	Moderately fast	0,51	0,58	0,54
BBE2	294,12	Very fast	405,47	Very fast	0,29	0,49	0,45
BBE2	461,54	Very fast	467,29	Very fast	0,34	0,50	0,46
BBE2	268,66	Very fast	257,12	Very fast	0,31	0,46	0,43
BBE2	345,16	Very fast	451,32	Very fast	0,43	0,56	0,52

Regarding the diversity of decomposing organisms, DNA of the 8 composite soil samples were extracted, obtaining an adequate DNA concentration to sequence the three target genomic regions (16S, ITS2, 18S). The quality of the extracted eDNA was evaluated by measuring absorbance at 260 nm and 280 nm and its ratio, and the majority of the samples presented a ratio around 1.8 which is generally accepted as "pure" for DNA.

In a preliminary analysis of soil DNA results, we found the most abundant Fungi identified were Ascomycota, followed by Basidiomycota, Mortierellomycota, Glomeromycota and Mucoromycota, being in accordance with what is known for dryland microbiome (Coleine et al., 2024) (Figure 14a). The samples from grazing exclusion areas (E) present in general less abundance of Chytridiomycota than the areas with grazing. This may be related with the fungi provenance from animal faeces in grazed samples as there is a known association between chytrid fungi and ruminant mammals, the pasture that contain resistant stages of the chytrids coming from the cattle faeces (Moore et al. 2020) (Figure 14a). Additionally, Fungi Beta diversity analysis revealed a clear separation between plots where grazing was excluded (BBE, ABE, BAE, AAE), indicating that the fungal communities in excluded plots are distinct from those in areas where grazing is present (Figure 15). The exclusion of grazing likely creates different conditions, such as changes in soil composition, moisture levels, and plant diversity, which in turn influence the composition and diversity of fungal communities.

Regarding bacterial phylum in the soil, in general, members of Actinobacteria, Alphaproteobacteria, and Chlo-roflexi dominate drylands, while Proteobacteria, Actinobacteria, Acidobacteria, Planctomycetes, Chloroflexi, Verrucomicrobia, Bacteroidetes, Gemmatimonadetes, Firmicutes, Armatimonadetes, TM7, and WS2 dominate in arable soils (Delgado-Baquerizo et al., 2018; Wierzchowski et al., 2021; Fierer et al., 2007). In the samples analysed, all plots presented the abovementioned bacterial phylum, however one of the grazing exclusion plots (BBE) showed a distinct blend with Bacteroidota, Verrucomicrobiota and Patescibacteria as the most abundant Phyla while Chloroflexi, Acidobacteria and Actinobacteria presented very low abundance (Figure 14b). Bacteroidota are important for the proper functioning of soil and chemical parameters have a strong influence on their abundance in soil (Kruczyńska et al., 2023). Patescibacteria are a recently discovered lineage that is widespread in various environments, including wetter places, like groundwater and freshwater (Chaudhari et al., 2021; Chiriac et al., 2022), indicating that this exclusion plot could probably have more humidity that the others. Nevertheless, these preliminary observations will be complemented with the ongoing thorough analysis of the data, and of their relationship with the environmental factors under study, which will provide more robust results concerning soil diversity patterns.

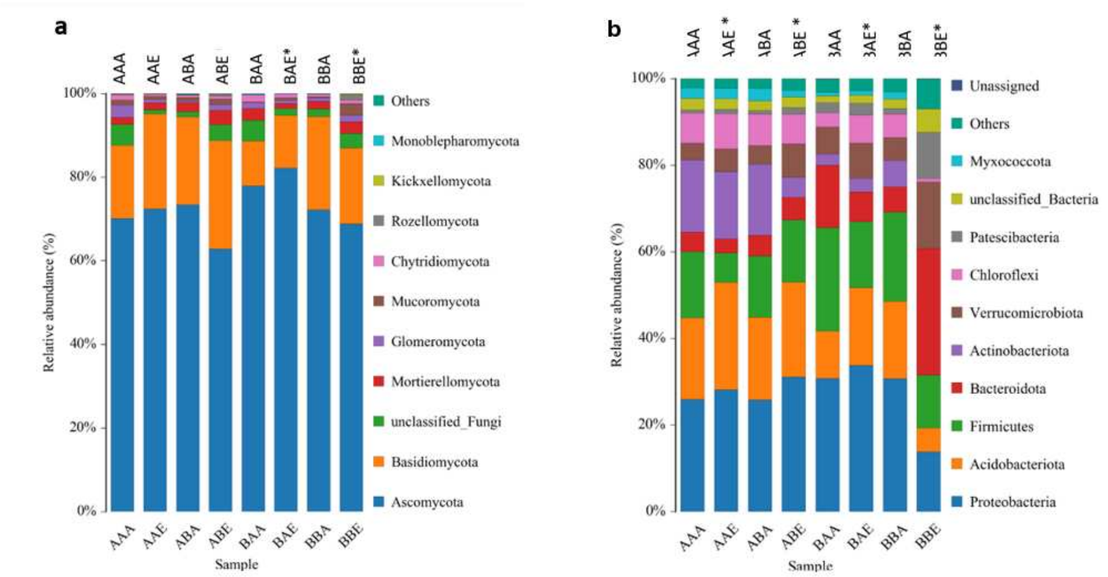

Figure 14. Fungi -Phylum (a) and Bacteria-Phylum (b) taxonomic distribution in all soil samples collected at Herdade da Coitadinha. Sample codes refer to the 8 treatments that result from the combination of tree cover (high and low), Potential Solar Radiation (high and low) and presence or absence of grazing, respectively (A – high; B – low, E - exclusion; e.g. the ABE code indicates high tree density (A), low PSR (B) and exclusion from grazing (E)).

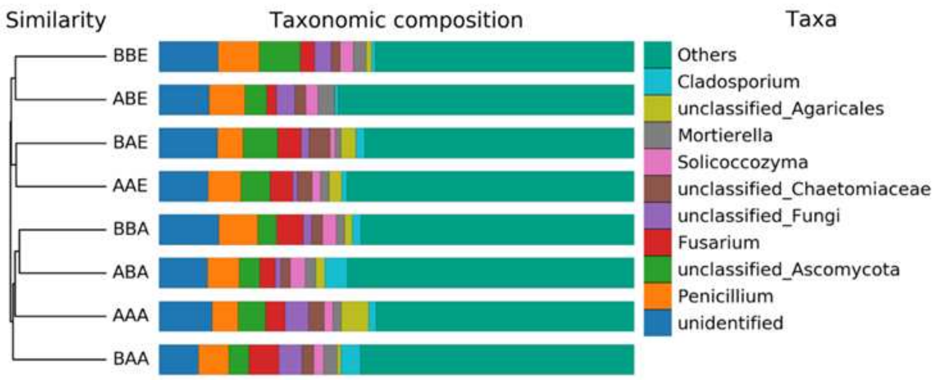

Figure 15. Clustering tree and histogram for Fungi Beta diversity analysis, UPGMA Clustering Tree with Taxonomic Composition in all samples collected at Herdade da Coitadinha. Sample codes refer to the 8 treatments that result from the combination of tree cover (high and low), Potential Solar Radiation (high and low) and presence or absence of grazing, respectively (A – high; B – low, E - exclusion; e.g. the ABE code indicates high tree density (A), low PSR (B) and exclusion from grazing (E)).

A5. Co-building and disseminating the best solutions to restore ES

In the context of Activity A5, a report containing local restoration measures to promote the natural regeneration of cork oak and holm oak and enhance the ecosystem services of the montado was successfully produced in the previous Report 3 (5.1.Report on restoration measures at local scale.docx). The local stakeholder workshop was concluded in 2022 as described in the Interim Report 1 (Local Workshop evidence).

The workshop for regional stakeholders (and LandUnderPressure project final seminar) happened on the 19th March 2024, in collaboration with ADPM (EEA Grants project +SOLO+VIDA) at the Pavilhão Multiusos de Mértola, as previously described. We hosted 27 participants, including farmers from this region, and representatives of relevant entities such as ICNF (see more details in Regional workshop evidence). After that the report with regional restoration measures was developed and it is disseminated in the website of the project (5.2. Report on restoration measures at regional scale).

Two videos about the LandUnderPressure project were developed, a longer one (~ 8min) focusing in explaining the whole context of the project and a short version (<2 min) with a brief introduction of the project. The videos were disseminated in the cE3c Instagram (https://www.instagram.com/reel/C7hISfBMjjx/?igsh=cThyaGR6M216ZzZn), E-changes YouTube channel (https://youtu.be/Q-N3g6z7hWk , https://youtu.be/MH3sOcyHhcMhttps://youtu.be/MH3sOcyHhcM), cE3c twitter (https://x.com/ce3cresearch/status/1795499752630407536?s=46&t=VlpsEED7M5t3vCMpzZSrWQ) and also on the website of the project. As of now, six days after the post, it has garnered 355 views, 94 likes, and 5 reposts in total.https://youtu.be/Q-N3g6z7hWk , https://youtu.be/MH3sOcyHhcMhttps://youtu.be/MH3sOcyHhcM), cE3c twitter (https://x.com/ce3cresearch/status/1795499752630407536?s=46&t=VlpsEED7M5t3vCMpzZSrWQ) and also on the website of the project. Six days after the post, it has garnered 355 views, 94 likes, and 5 reposts in total.

The content of the ebook and the informative graphics (as part of the ebook) have also been finalized and the design is in the final stage of development. After that it will be posted on the website of the project and distributed by email to the local and regional stakeholders that were present in the two workshops and disseminated to the public. The informative graphics will be also used as part of other publications related to the project.

Table 5 presents the indicators of project results, and it shows that, overall, the project has achieved its goals. This indicates that the LandUnderPressure project progressed as planned and we successfully accomplished its objectives.

Table 5. Project result indicators until April 2024.

ID	Description of the Activity	Indicator	Unit	Goal	Results until 04.2024
1	Establishing a productivity baseline at the regional scale	1.1. Geographical Information system database of the montado areas	nº	1	1
1	Establishing a productivity baseline at the regional scale	1.2. Geographical Information system database with mapped baseline productivity	nº	2	2
1	Establishing a productivity baseline at the regional scale	1.3. Geographical Information system database with productivity trend classification	nº	1	1
1	Establishing a productivity baseline at the regional scale	1.4. Statistical multivariate model explaining the productivity's spatial heterogeneity	nº	1	1
2	Restoring degraded areas by managing grazing intensity	2.1. Map of the potential natural regeneration in the pilot project	nº	1	1
2	Restoring degraded areas by managing grazing intensity	2.2. Statistical model for tree density	nº	1	1
2	Restoring degraded areas by managing grazing intensity	2.3. Map of tree density of the pilot project	nº	1	1
2	Restoring degraded areas by managing grazing intensity	2.4.Methodological protocol for the evaluation of grazing intensity	nº	1	1
2	Restoring degraded areas by managing grazing intensity	2.5. Geographic database of areas subject to restoration	nº	1	1
2	Restoring degraded areas by managing grazing intensity	2.6. Geographic database of grazing intensity	nº	1	1

ID	Description of the Activity	Indicator	Unit	Goal	Results until 04.2024
3	Quantify Ecosystem Services (ES) in restoration and in drought scenarios	3.1. Database of herbaceous biomass	nº	1	1
3	Quantify Ecosystem Services (ES) in restoration and in drought scenarios	3.2. Database of acorn biomass	nº	1	1
3	Quantify Ecosystem Services (ES) in restoration and in drought scenarios	3.3. Database with the demography of oaks	nº	1	1
3	Quantify Ecosystem Services (ES) in restoration and in drought scenarios	3.4. Database of abundance. and div. of plants	nº	1	1
3	Quantify Ecosystem Services (ES) in restoration and in drought scenarios	3.5. Database of bird's abundance and diversity in restoration areas	nº	1	1
3	Quantify Ecosystem Services (ES) in restoration and in drought scenarios	3.6. Database of carbon sequestration by vegetation	nº	1	1
3	Quantify Ecosystem Services (ES) in restoration and in drought scenarios	3.7. Database of microclimatic data	nº	1	1
3	Quantify Ecosystem Services (ES) in restoration and in drought scenarios	3.8. Database with questionnaire results	nº	1	1
3	Quantify Ecosystem Services (ES) in restoration and in drought scenarios	3.9. Statistical models explaining the impact of restoration measures in soil ES delivery	nº	1	1
3	Quantify Ecosystem Services (ES) in restoration and in drought scenarios	3.10. Report on the impact of restoration measures on the delivery of several ecosystem services and their trade-offs	nº	1	1
4	Assessment of soil ES in restoration areas	4.1. Database of soil water balance	nº	1	1
4	Assessment of soil ES in restoration areas	4.2. Database of soil organic matter and organic carbon	nº	1	1
4	Assessment of soil ES in restoration areas	4.3. Database of soil nutrients content	nº	1	1
4	Assessment of soil ES in restoration areas	4.4. Database of litter decomposition rate	nº	1	1
4	Assessment of soil ES in restoration areas	4.5. Database on the diversity of decomposer organisms	nº	1	1
4	Assessment of soil ES in restoration areas	4.6. Database of soil loss	nº	1	1
4	Assessment of soil ES in restoration areas	4.7. Statistical model	nº	1	1

ID	Description of the Activity	Indicator	Unit	Goal	Results until 04.2024
5	Co-building and disseminating the best solutions to restore ES	5.1. Report on restoration measures at local scale	nº	1	1
5	Co-building and disseminating the best solutions to restore ES	5.2. Report on restoration measures at regional scale	nº	1	1
5	Co-building and disseminating the best solutions to restore ES	5.3. Workshop for local stakeholders	nº particip	10	9
5	Co-building and disseminating the best solutions to restore ES	5.4. Workshop for regional stakeholders	nº particip	25	27
5	Co-building and disseminating the best solutions to restore ES	5.5. Development and dissemination of an electronic book	nº vis/ year	100 vis./ ano	0*
5	Co-building and disseminating the best solutions to restore ES	5.6. Development and dissemination of informative graphics	nº vis/ year	100 vis./ ano	0*
5	Co-building and disseminating the best solutions to restore ES	5.7. Development and dissemination of an animated video	nº vis/ year	500 vis./ ano	355vis./6 days
Man.		Final Report (5)	nº	5	5

*It was recently developed and will be openly disseminated soon, therefore there are no visualizations by now.

Table 6 presents a summary of the technical execution against the defined schedule. Despite a slight delay in starting some sub-tasks or other adjustments, project execution generally followed the defined plan.

Table 6. Summary of technical execution against the schedule. The orange color indicates the initial period foreseen, and the blue one indicates the actual period, including the extension of the project until April 2024.

				2022						**2023**												**2024**			
ID	**Description of the Activity**	**Indicator**	**Exec.**	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
A1. Establishing a productivity baseline at the regional scale																									
1.1	Geographic database of montado areas	Delimitation of the selected montado areas	100%																						
1.2	Geographic database with productivity maps	Maps of reference productivity in montados for 2015-2021	100%																						
1.3	Geographic database with productivity trends	Classification of selected areas on a regional scale	100%																						

				2022						2023												2024			
ID	**Description of the Activity**	**Indicator**	**Exec.**	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
		for the period 2015-2021																							
1.4	Multivariate statistical model	Model spatial productivity heterogeneity	100%																						
A2. Restoring degraded areas by managing grazing intensity																									
2.1	Map of the natural regeneration potential	Map of the natural regeneration potential in HC	100%																						
2.2	Statistical model of tree density	Calibration model between NDVI and tree density	100%																						
2.3	Map of the estimated tree density	Map with estimated tree density for HC	100%																						
2.4	Protocol for grazing intensity evaluation	Protocol for assessing grazing intensity	100%																						
2.5	Geographic database of areas subject to restoration	Location of the 60 sampling plots (90ha) subject to restoration measures	100%																						
2.6	Geographic database of grazing intensity	Estimated grazing intensity for the 60 sampling plots	100%																						
A3. Quantify Ecosystem Services (ES) in restoration and in drought scenarios																									
3.1	Database of herbaceous biomass	Database of herbaceous biomass in restoration areas	100%																						
3.2	Database of acorn biomass	Database of acorn biomass in rest. areas	100%																						
3.3	Database with the demography of oaks	Database with demography of oaks in rest. areas	100%																						
3.4	Database of plants abundance and diversity	Database of plants abundance and diversity in rest. areas	100%																						
3.5	Database of bird's abundance and diversity	Database of bird's abundance and diversity in rest. areas	100%																						
3.6		Database of carbon	100%																						

				2022						2023												2024			
ID	**Description of the Activity**	**Indicator**	**Exec.**	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
	Database of carbon sequestration	sequestration by vegetation																							
3.7	Database of microclimatic data	Database of microclimatic data in rest. areas	100%																						
3.8	Database of the results of the questionnaires	Database of results from questionnaires on restored landscapes carried out among tourists	100%																						
3.9	Statistical models of the impact of restoration measures on ES	Statistical model of the effects of measures on ES	100%																						
3.10	Report on the impact of restoration measures on ES	Report describing the effects of restoration measures on ES	100%																						
A4. Assessment of soil ecosystem services in restoration areas																									
4.1	Database of soil water balance	Database of soil water balance in rest. areas	100%																						
4.2	Database of soil organic matter and organic carbon content	Database of soil organic matter and organic carbon content in rest. areas	100%																						
4.3	Database of soil nutrient content	Database of soil nutrient content in restored areas	100%																						
4.4	Database of litter decomposition rate	Database of litter decomposition rate in rest. areas	100%																						
4.5	Database of the diversity of decomposing organisms	Database of the diversity of decomposing organisms in rest. areas	100%																						
4.6	Database of soil loss	Database of soil loss in restored areas	100%																						
4.7	Statistical models	Statistical models	100%																						
A5. Co-buildimg and disseminating the best solutions to restore ES																									

				2022						2023												2024			
ID	Description of the Activity	Indicator	Exec.	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
5.1	Report with local restoration measures	Report on collaborative restoration solutions at the local scale	100%																						
5.2	Report with regional restoration measures	Report on collaborative restoration solutions at the regional scale	100%																						
5.3	Workshop for local stakeholders	Organization & participation in the 1st workshop for local actors	100%																						
5.4	Workshop for regional stakeholders	Workshop for regional stakeholders	100%																						
5.5	Develop. and dissemination of electronic book	Develop. and dissemination of electronic book	100%																						
5.6	Develop. and dissemination of informative graphics	Develop. and dissemination of informative graphics	100%																						
5.7	Develop. and dissemination of an animated video	Develop. and dissemination of an animated video	100%																						
Man	Interim report		100%						**R**				**R**					**R**			**R**				**R F**

In short, the purchase of the GPS collars to track cattle movements was somewhat delayed due to the difficulty in acquiring the initially selected models, for bureaucratic reasons and the scarcity of national suppliers (that do not sell some of the initially selected models). The collars were purchased, and after agreement with the managers of the Herdade da Coitadinha about a suitable time for placing them on the cows, they were implemented in March 2024. We have already collected preliminary data, showing good coverage, particularly for the SigFox technology. As more time is needed to gather robust data on animal movement, we plan to use these results to analyse livestock distribution and grazing pressure on a landscape scale. This information will be invaluable in supporting grazing management to enhance montado resilience. For example, it will allow us to propose tailored restoration solutions for areas with varying grazing pressures, such as installing individual protectors or creating grazing exclusion zones.

In activity A4, despite the field monitoring work being completed successfully, the delay in delivering some of the planned outputs was due to the difficulty in contracting services e.g. for physical-chemical and metagenomic analysis of the soil, for bureaucratic reasons. Soil samples were collected in 2023. Part of the samples were prepared and sent for physical-chemical analysis (contracting the service took longer than expected), the results of which were recently received (with some delays on the company's part) and have already been integrated into the database available at 4.3.Soil nutrient content database . For the other part of the soil samples, DNA was extracted in FCUL labs, and a quality assessment was made to ensure an adequate amount and quality of DNA. Then, soil DNA samples were sent for metagenomic analyses (to the German company BMKGENE). The results of the analysis were only received recently and a database of soil microorganisms per sample was already made available on the project website (4.5. Database on the diversity of decomposer organisms). Soil DNA data analysis is ongoing, and we are planning to produce a scientific paper to be submitted by the end of 2024.

Additionally, as previously mentioned, Herdade da Coitadinha is a long-term ecological research site. We plan to continue monitoring natural regeneration and other ecosystem service indicators (e.g., herbaceous plants, insect and bird diversity) in the small-fenced areas and adjacent control areas. The impact of this restoration measure on other ecosystem services will require more time to detect, so its assessment will need to be conducted in the medium to long term.

Future plans also include the submission and publication of two scientific papers in high-quality journals by the end of this year. The first paper will cover the information in A1, focusing on productivity trends and spatial heterogeneity of Montados. The second paper will examine the impact of restoration measures on the provision of ecosystem services, including soil-related aspects (A2, A3, A4).

Small adjustments to the budget regarding the transfer of funds between items were requested and authorized, namely the transfer of €566.60 from services to missions, and €133.40 from consumables to missions, resulting in a reinforcement of €700 for missions, to support the costs of carrying out and traveling to the final seminar of the project held simultaneously with the regional workshop for actors, in Mértola in March 2024, planned from the beginning in the project, but initially under-budgeted.

Communication Plan

As it was already mentioned in the previous Interim Reports, several activities were developed within the scope of the Communication Plan: 1) the graphic image of the project; 2) the communication dossier, 3) a video with a summary of the project, 4) the project website (https://landunderpressure.wixsite.com/landunderpressure), 5) the project identification plate implementation in the field (as demonstrated in Figure 6 of the Interim Report 2), 6) news and scientific presentations were published in different media types (e.g. twitter, website, newsletter, scientific conferences). From January to April 2024 extra activities were performed and added to

Table 7 marked by "New" in red), with the cumulative description of the disseminating actions performed during the project.

Table 7. Communication chronogram and evidence of the project until the end of the project, April 2024.

Activity	Expected date	Date performed	Evidence
Graphic image of the project	Sep 2022	Sep 2022	A graphic image of the project, including the EEA Grants logo, was developed following the EEA Grants 2014-2021 communication manual and graphic standards. This image is used in various communication materials developed and to be developed as part of the project. Imagem de verificação no relatório 1, página 22.
Creation of a website	Nov 2022	Nov 2022	https://landunderpressure.wixsite.com/landunderpressure
Creation of social networks and publications	Dec 2023	Dec 2023	Project activities have also been disseminated through associated social media accounts, for example, the cE3c research center (Twitter and newsletter), to which some of the team's researchers belong (e.g. post related to the fieldwork season). Verificação no relatório 3 ,4
Communication dossier	Dec 2023	Dec 2023	A Communication Dossier was created and made available in the folder indicated by EEA Grants, where the requested and relevant information for communication purposes has been placed. Verificação no relatório 1 (https://drive.google.com/drive/folders/17PpFgKbOrAQiMI5H5oAwmD4hKYC9eV45)
1º Workshop and opening event of the project	Dec 2022	Dec 2022	Workshop 1 with stakeholders and opening event of the project held on the 6th December 2022 at Herdade da Coitadinha, Barrancos. Verificação Relatório 1 página 5 and 1 Workshop
Questionnaire on the perception of cultural services by visitors and tourists at HC	Feb 2023	Jun 2023	The Master's thesis in Environment and Resource Management by ERASMUS+ student Magdalena Lesch from Vrije Universiteit Amsterdam entitled "Preferences for Montado Restoration as a Function of Cultural Ecosystem Services, Environmental Attitude, and Place Identity: A case study on the Herdade da Coitadinha" was successfully approved in June 2023. The thesis focused on the questionnaire assessing visitors' and tourists' perceptions of cultural services at HC.The survey was made available online (https://vuamsterdam.eu.qualtrics.com/jfe/form/SV_5otkX9EqT76yEyW).

Activity	Expected date	Date performed	Evidence
Webinar interacting with iLTER network	May 2023	Apr 2023	Participation in the eLTER-Consortia Meeting Frankfurt-Germany, April 17-21, 2023 with a poster including information about the LandUnderPressure project with the reference: "Reis B., Köbel M., Príncipe A., Rosário I., Santos-Reis M., Domingues I., Oliveira A., Serrano H., Branquinho C., A. Nunes. Monitoring, restoring and adapting Portuguese agro-forestry systems to enhance resilience to climate change. eLTER-Consortia Meeting Frankfurt-Germany, April 17-21, 2023." The poster is available in the project's Communication Dossier and received the best poster award at the conference, as reported on the project's website (https://landunderpressure.wixsite.com/landunderpressure/post/exciting-news-land-under-pressure-was-awarded-with-the-best-poster-in-the-elter-meeting-in-frankfurt). https://drive.google.com/drive/folders/1V010ITWonnS1A7yMHWErrQF2-xxDfL7Q Verificação no relatório 2
2 participatory workshops for co-creation of restoration areas + closing Event of the project	Ago 2023	Mar 2024	The final seminar + workshop with regional actors was held in 19/03/2024, in partnership with ADPM (project +solo + vida), in Mértola. Verification report 5 and : 2 Workshop
Social media and website posts	Dec 2023	Dec 2023	A news article was published on the cE3c website, to which the FCUL promoter team belongs, on the day of the project contract signing on June 17 in Mogadouro Verificação no relatório 2 https://ce3c.ciencias.ulisboa.pt/outreach/press&events/ver.php?id=1411 A news article was published in the eLTER Integrated European Long-Term Ecosystem, critical zone, and socio-ecological Research newsletter and then disseminated through the project website. Verificação no relatório 2 https://landunderpressure.wixsite.com/landunderpressure/post/como-agilizar-o-workflow-da-ciência-de-dados A news article was published on the project website about the workshop with local stakeholders and the ICNF's follow-up visit to the pilot restoration at Herdade da Coitadinha on December 6, 2022. https://landunderpressure.wixsite.com/landunderpressure/post/icnf-on-a-follow-up-visit-to-the-landunderpressure-project A post was made in the website of the project with interesting details of the sampling season developed from April to June 2023. Verificação no relatório 3 (https://landunderpressure.wixsite.com/landunderpressure/post/spring-sampling-is-already-done)

Activity	Expected date	Date performed	Evidence
			A post was made in the website of the project with interesting details of the Lab work developed from September to December 2023. (https://landunderpressure.wixsite.com/landunderpressure/post/biodiversity-in-the-lab)
Congress and seminars participation	Dec 2023	Dec 2023	Verificação no relatório 2, 3 e 4 Participation in the webinar and roundtable "Conversations about the Land: The montado and climate change, a vision for the future," organized by ADPM – Associação de Defesa do Património de Mértola and the LIFE Desert-.Adapt project, April 13, 2023. Participation in the Workshop de zonas semiáridas: Problemas e soluções, experiências de Portugal e do Brasil, 19th June 2023, Universidade de Lisboa, with na oral presentation about "Experiências de restauro em zonas semiáridas. Uma visão a longo prazo", made de by B. Reis. (https://drive.google.com/drive/folders/1V010ITWonnS1A7yMHWErrQF2-xxDfL7Q) An oral presentation was given, including information about the LandUnderPressure project, as part of the webinar and roundtable "Conversations about the Land: The montado and climate change, a vision for the future," organized by ADPM – Associação de Defesa do Património de Mértola and the LIFE Desert-.Adapt project, with the reference: "Nunes A. Oral presentation and participation in the roundtable: Conversas sobre a Terra: O montado e as alterações climáticas, uma visão para o futuro. Organized by ADPM – Associação de Defesa do Património de Mértola and LIFE Desert-.Adapt project, April 13, 2023. Verificação no relatório 2 A poster presentation was made, including information about the LandUnderPressure project, as part of the Ciências Research Day at the Faculty of Science, University of Lisbon, on October 26, 2022, with the reference: "Köbel M., Príncipe A., Reis B.P., Domingues I., Oliveira A., Serrano H., Nunes A. & C. Branquinho (2022). Monitoring, restoring, and adapting agroforestry systems to enhance resilience to climate change. Presentation in panel in Ciências Research Day, October 26, 2022, Lisbon, Portugal." The poster is available in the project's Communication Dossier. https://drive.google.com/drive/folders/1V010ITWonnS1A7yMHWErrQF2-xxDfL7Q Verificação no relatório 2 A poster presentation was made, including information about the LandUnderPressure project with the reference: "Reis B., Köbel M., Príncipe A., Rosário I., Santos-Reis M., Domingues I., Oliveira A., Serrano H., Branquinho C., A. Nunes. Monitoring, restoring and

Activity	Expected date	Date performed	Evidence
			adapting Portuguese agro-forestry systems to enhance resilience to climate change. eLTER-Consortia Meeting Frankfurt-Germany, April 17-21, 2023." The poster is available in the project's Communication Dossier and received the best poster award at the conference, as reported on the project's website (https://landunderpressure.wixsite.com/landunderpressure/post/exciting-news-land-under-pressure-was-awarded-with-the-best-poster-in-the-elter-meeting-in-frankfurt). https://drive.google.com/drive/folders/1V010ITWonnS1A7yMHWErrQF2-xxDfL7Q Verificação no relatório 2 An oral presentation was made, including information about the LandUnderPressure project with the reference: "Nunes A., Serrano H., Salgueiro P.A., Marques C., Calvão C., Branquinho C. (2023). Ecological restoration in Portugal: network collaboration to inform national and European nature restoration policies. Oral presentation in the scientific meeting Science CHANGing Policy, organized by CHANGE - Global Change and Sustainability, June 2, 2023, University of Évora, Portugal." Verification in report 2. Verificação no relatório 2 An oral presentation was made: Nunes A. et al. (2023). Science-based ecological restoration to inform national and European restoration policies. Oral presentation in the Encontro Scientia, 15th June 2023, Universidade de Lisboa, Portugal. Verificação no relatório 3 An oral presentation was made: Reis B. P. (2023) Experiências de restauro em zonas semiáridas. Uma visão a longo prazo. Oral presentation in the Workshop de zonas semiáridas: Problemas e soluções, experiências de Portugal e do Brasil, 19th June 2023, Universidade de Lisboa, Portugal. Verificação no relatório 3 https://drive.google.com/drive/folders/1V010ITWonnS1A7yMHWErrQF2-xxDfL7Q A poster presentation was made, including information about the LandUnderPressure project: Reis B. P., Köbel M., Príncipe A., Rosário I., Santos-Reis M., Domingues I., Oliveira A., Serrano H., Branquinho C., A. Nunes. Monitoring, restoring and adapting portuguese agro-forestry systems to enhance resilience to climate change (2023). Poster presentation at 9º Encontro Anual do cE3c - Frontiers in E3, 7-9 September 2023, Lisboa, Portugal. (https://drive.google.com/drive/folders/1V010ITWonnS1A7yMHWErrQF2-xxDfL7Q) An oral presentation was given, as part of 10th World Conference on Ecological Restoration: Reis B. P., Török K., Nunes A., Branquinho C. & Halassy M. (2023). The added value of the eLTER site network and community to upscale restoration in Europe. Oral presentation in the 10th World Conference on Ecological Restoration (SER), 26-30 Sept. 2023, Darwin, Australia.

Activity	Expected date	Date performed	Evidence
			An oral presentation was given, including information about the LandUnderPressure project: Nunes A., Köbel M., Príncipe A., Reis B. P., Domingues I., Ramos M., Oliveira A., Serrano H., Branquinho C. (2023). Monitoring, restoring, and adapting agroforestry systems to increase resilience to climate change. Oral presentation in the 10th World Conference on Ecological Restoration (SER), 26-30 Sept. 2023, Darwin, Australia. (https://drive.google.com/drive/folders/1V010ITWonnS1A7yMHWErrQF2-xxDfL7Q) A poster presentation was made, including information about the LandUnderPressure project, as part of Encontro Nacional de Ecologia: Köbel M., Reis B. P., Príncipe A., Rosário I., Santos-Reis M., Domingues I., Oliveira A., Serrano H., Branquinho C., A. Nunes. Monitoring, restoring and adapting portuguese agro-forestry systems to enhance resilience to climate change (2023). Poster presentation at Encontro Nacional de Ecologia, 22-25 November 2023, Faro, Portugal. https://drive.google.com/drive/folders/1V010ITWonnS1A7yMHWErrQF2-xxDfL7Q An oral presentation was made: Reis B. P., Török K., Nunes A., Branquinho C. & Halassy M. (2023). Enhancing Restoration Ecology in Europe: The Impact of the eLTER Community on Upscaling Ecological Restoration Efforts. Oral presentation at Encontro Nacional de Ecologia, 22-25 November 2023, Faro, Portugal. An oral presentation was made in the open day at Herdade da Coitadinha: Köbel M, Reis B, Príncipe A, Domingues I, Rosário I, Santos-Reis M, Oliveira A, Serrano H, Branquinho C, Nunes A, 2024. Projectos Land Under Pressure e Renewal em Noudar - Monitorizar, restaurar e adaptar sistemas agroflorestais para aumentar a resiliência às alterações climáticas. Dia aberto Parque de Natureza de Noudar, 8 Maio 2024. Barrancos.
Ebook	Dec 2023	Apr 2024	https://drive.google.com/file/d/1BoVBNELqSaLGOkZ8PZfH8H2do3xDXFtI/view
Infographics	Dec 2023	Apr 2024	Infographics were developed and made available in the ebook (https://drive.google.com/file/d/1BoVBNELqSaLGOkZ8PZfH8H2do3xDXFtI/view)
Videos	Dec 2023	Apr 2024	2 videos were produced a short one a longer one with subtitles in English about the project (https://youtu.be/Q-N3g6z7hWk , https://youtu.be/MH3sOcyHhcM, https://youtu.be/zpnZQCavjSM)
Project identification plaque	Mar 2022	Mar 2022	A project information plaque was installed in the field, in the area of the pilot test, at Herdade da Coitadinha. Imagem de verificação no relatório 2, página 21.
Submission of articles to peer-reviewed	Dec 2023	Apr 2024	An article was submitted and is under revision to the journal Ecological Indicators, entitled "Local environmental factors with high spatial resolution explain tree mortality in Mediterranean oak woodlands".

Activity	Expected date	Date performed	Evidence
scientific journals (≥2)			An article related to long-term restoration areas in Europe was submitted and in final revision round in the Journal of Environmental Management with reference: Reis B. P., Branquinho C., Török K., Nunes A. and Halassy M. (2024) The added value of the eLTER community to upscale restoration in Europe. Published article: Eldridge, D.J., Ding, J., Dorrough, J., ... Köbel M., ... Nunes, A., ... & F. Maestre (2024). Hotspots of biogeochemical activity linked to aridity and plant traits across global drylands. Nature Plants. https://doi.org/10.1038/s41477-024-01670-7

iii. Description of costs and financial impact assessment

Regarding the project expenses for the period under review for both the project promoter and partners, the expenses incurred up to April 2024 are presented below.

In Table 8, a summary of the costs incurred by the project promoter (FCUL) and the partner (IPB) is provided.

Table 8. Summary of costs incurred from January to April 2024, by entity.

Entity/	Expenses				Financial execution rate (%)	
	(with indirect costs)				(compared to total cost)	
Activity	in reporting period	Cumulative	Presented to PP	To present in next PP	in reporting period	Cumulative
FCUL	74 625,66 €	290 556,12 €	163 180,86 €	127 375,25 €	25,68	99,97
IPB	25 739,44 €	45 396,03 €	13 243,99 €	32 152,04 €	43,71	77,09
TOTAL	100 365,10 €	335 952,15 €	176 424,85 €	159 527,31 €	28,71	96,12

Tables 9 and 10 present summaries of the costs carried out by each activity and project partner, with the project's overall financial execution rate being 96%.

Table 9. Summary of costs incurred by activity and partner in the reporting period (January to April 2024) and cumulatively.

Entity	**Expenses**				**Finantial execution rate (%)**	
	(with indirect costs)				**(compared to total cost)**	
Activity	in reporting period	Cumulative	Presented to PP	To present in next PP	in reporting period	Cumulative
Management						
FCUL	2 181,85	85 693,03	65 096,30	20 596,73	2,34	91,75
IPB	8 391,44	15 609,88	5 958,46	9 651,42	60,79	113,07
Total manag.	10 573,29	101 302,91	71 054,76	30 248,15	9,86	94,50
A1						
FCUL	9 363,12	38 003,14	21 039,51	16 963,62	23,42	95,04
IPB						
Total A1	9 363,12	38 003,14	21 039,51	16 963,63	23,42	95,04
A2						
FCUL	11 690,55	52 507,83	36 209,62	16 298,20	25,38	114,01
IPB						
Total A2	11 690,55	52 507,83	36 209,62	16 298,21	25,38	114,01
A3						
FCUL	21 856,11	60 865,72	26 371,40	34 494,32	37,64	104,83
IPB						
Total A3	21 856,11	60 865,72	26 371,40	34 494,32	37,64	104,83
A4						
FCUL	15 925,62	22 983,49	4 011,88	18 971,61	69,97	100,99
IPB	17 348,00	29 786,15	7 285,53	22 500,62	38,48	66,07
Total A4	33 273,62	52 769,64	11 297,41	41 472,23	49,05	77,79
A5						
FCUL	13 608,42	30 502,92	10 452,15	20 050,77	44,79	100,39
IPB						
Total A5	13 608,42	30 502,92	10 452,15	20 050,77	44,79	100,39
Total	100 365,10	335 952,15	176 424,85	159 527,31	28,71	96,12

Table 10. Summary of costs incurred by activity in the reporting period (January to April 2024) and cumulative.

Project/	Expenses				Finantial execution rate (%)	
	(with indirect costs)				(compared to total cost)	
Activity	in reporting period	Cumulative	Presented to PP	To present in next PP	in reporting period	Cumulative
Management	10 573,29	101 302,91	71 054,76	30 248,15	9,86	94,50
A1	9 363,12	38 003,14	21 039,51	16 963,63	23,42	95,04
A2	11 690,55	52 507,83	36 209,62	16 298,21	25,38	114,01
A3	21 856,11	60 865,72	26 371,40	34 494,32	37,64	104,83
A4	33 273,62	52 769,64	11 297,41	41 472,23	49,05	77,79
A5	13 608,42	30 502,92	10 452,15	20 050,77	44,79	100,39
Total	100 365,10	335 952,15	176 424,85	159 527,31	28,71	96,12

iv. Description of the Project's contribution to achieving the overall objectives of EEA Grants and the 'Environment Programme'

The LandUnderPressure project has contributed to the general objectives of the EEA Grants, which aim to reduce economic and social disparities within the European Economic Area. The project focuses on the drier territories of Portugal, particularly those most susceptible to desertification, which have been experiencing increasingly visible consequences of climate change, such as prolonged droughts, extreme weather events, rural exodus, land abandonment, and growing pressure from the expansion of intensive production areas. The project contributes to raising awareness and empowering key stakeholders regarding climate risks and sustainable methods of production and management in agroforestry and extensive grazing systems. Through its future actions, it aims to reduce vulnerabilities in semi-arid regions, promoting social and economic convergence with the European averages. Gender equality principles are promoted both within the technical team and in interactions with stakeholders.

The project aligns with the objectives of the Environment Program by promoting best practices for soil use and conservation to enhance soil physical and chemical quality.

LandUnderPressure also contributes to strengthening bilateral relations between Donor Countries and Beneficiary Countries by including a partner from one of the Donor Countries, Iceland, represented by (previously called) The Soil Conservation Service of Iceland, now called Land and Forest Iceland, with proven expertise and knowledge in ecological restoration and soil ecology. Our partner, Kristín Svavarsdóttir, came to Portugal having participated in the project's final seminar and the workshop with regional actors. Kristín brought her expertise in soil conservation and ecosystem restoration in Iceland, which she shared with the project's members during meetings, a field visit to the pilot project site, and an open presentation at FCUL (https://ce3c.ciencias.ulisboa.pt/outreach/press&events/ver.php?id=1563). Kristín´s contribution was important to the discussion of project data, being evident from both sides the interest and willingness to continue and strengthen this partnership in the future, as we share several research interests and working topics.

The project contributes to deepening and disseminating information about land degradation and its potential for ecological restoration, enhancing the capacity to assess and reduce vulnerability to climate change. It highlights the role of biodiversity in the functioning of montado agroforestry systems, contributing to the valorization of the territory.

Table 11 presents the project's contribution, in terms of specific indicators, to the objectives of the EEA Grants and the Environment Program.

Table 11. Project Contribution to the Objectives of the EEA Grants and the Environment Program.

Objective	Expected results	Indicador	Base value	Target	Project contributions	Related task
PA 13 Output 3	Increase resilience and responsiveness to climate change in specific areas	Number of hectares with reduced susceptibility to desertification	0	90 ha	90 ha	A02 e A05
	Pilot projects to combat desertification completed	Number of projects to combat desertification tested	0	1	1	A01, A02, A03, A04, A05

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Position	Secretary General

Annex I. Methods for calculating soil water balance and soil loss for Herdade da Coitadinha

1. Soil water balance

The calculation of soil water balance for Herdade da Coitadinha followed several methodological steps described in the following sections.

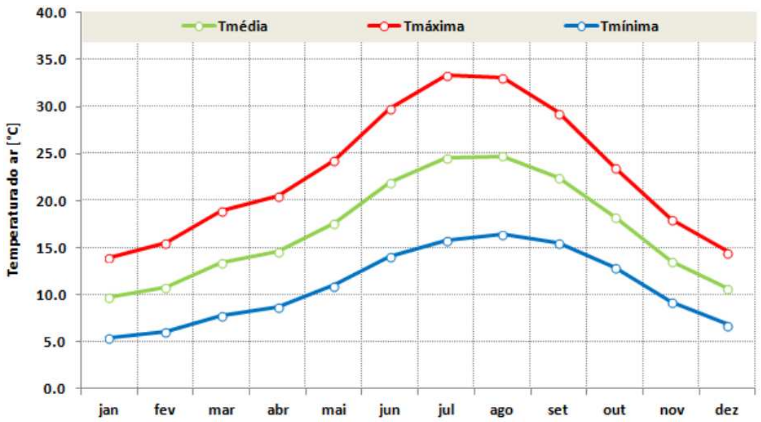
1.1 Choosing the meteorological station

Soil water balance calculations were based on meteorological data, such as temperature and rainfall, obtained from the climatological normals provided by the Portuguese Institute for the Sea and Atmosphere (IPMA). The municipality of Barrancos has a rain gauge station integrated into the National Water Resources Information System (SNIRH), which only provides rainfall data. In view of this, it was necessary to search for IPMA stations located close to the municipality and determine the one that best represented Barrancos' meteorological conditions.

Three nearby stations were identified: Beja, Elvas and Mértola. These stations were evaluated considering their geographical coordinates, rainfall and also by comparing the temperatures recorded between them, in order to determine which of them would be best suited to represent the meteorology of Barrancos. By comparing the rainfall recorded at these three stations with the rainfall data measured in Barrancos over a 30-year series, it was possible to see that they all represented the reference station fairly accurately. The coefficients of determination (R^2) obtained were significantly high, with values of 0.977, 0.972 and 0.974 for Beja, Elvas and Mértola, respectively. In addition, the slopes of the linear regression lines were close to unity, indicating a strong, positive linear relationship between the data from the stations considered and that from Barrancos, with values of 1.06, 1.02 and 0.92 for Beja, Elvas and Mértola, respectively.

The IPMA graphs show that the three stations are very similar in terms of the temperatures recorded (Figure A1).

a)



b)

c)

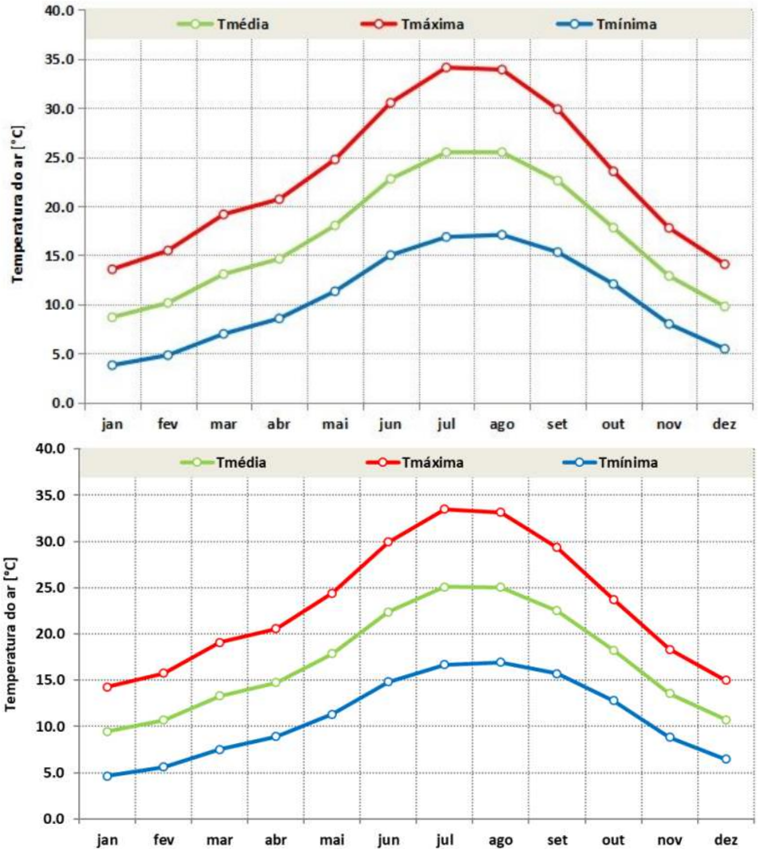


Figure A1. Average (green), maximum (red) and minimum (blue) temperature normals in the 1981 to 2010 time series for a) Beja, b) Elvas and c) Mértola.

Therefore, the Beja weather station was chosen to meteorologically represent the Barrancos area, as it is at a closer latitude (38.0257) to Barrancos (38.1315) than the other stations, Elvas (38.8896) and Mértola (37.7575).

1.2 Calculation of the reference evapotranspiration and soil water balance

The Thornthwaite method was used to calculate reference evapotranspiration (ETP), based on the average monthly air temperature of the Beja meteorological station. The Thornthwaite method requires little input data, such as air temperature and latitude of the location, as well as being simple to calculate.

The Thornthwaite-Mather method was used to calculate the soil water balance, using ETP and precipitation as input data. The output variables were soil water storage (A), change in storage (dA), actual evapotranspiration (ETR), soil water deficit (D) and soil water surplus (S). Using this method, it was possible to calculate all these variables in monthly and annual values for the data series from 1989 to 2018 for the Beja meteorological station.

After calculating the water balance over the 30 years of the data time series, it was possible to obtain the annual average of each of the variables over the years (Figure A2). In the first year of calculation, a storage of 100mm was taken as the maximum storage reference and, over the months and years, this storage changed according to rainfall and potential evapotranspiration.

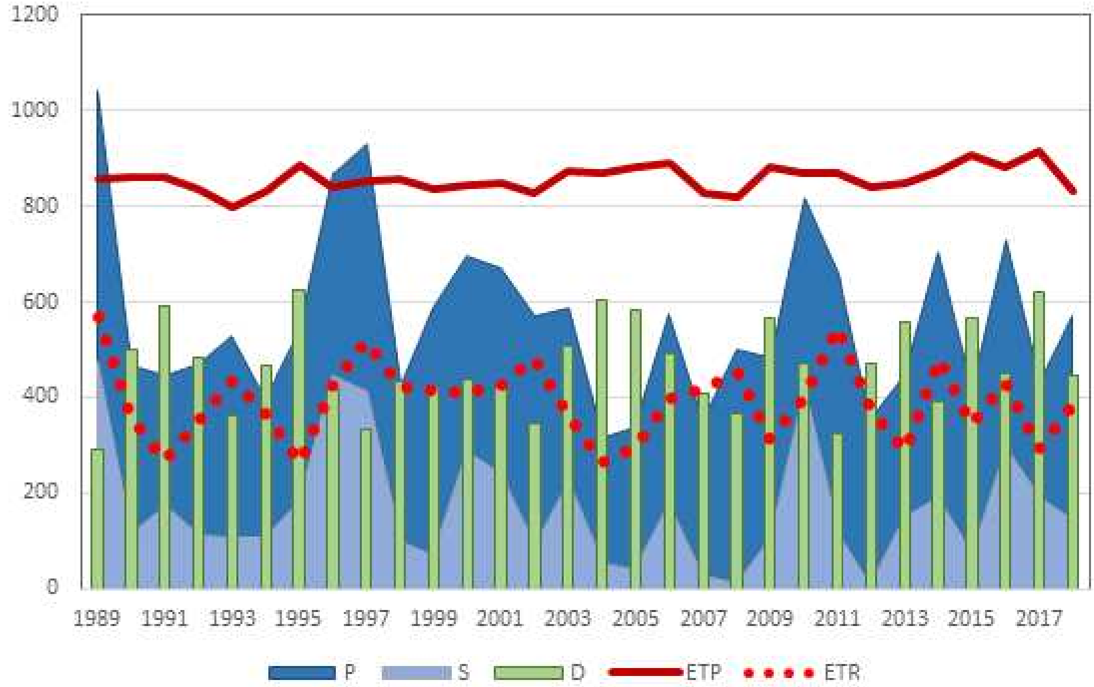


Figure A2. Temporal variation of the water balance.

Looking at the graph, it is clear that precipitation (P) was the variable most susceptible to changes over the years, with values of over 1000 mm in 1989 and less than 400 mm per year in 2004, while potential evapotranspiration (ETP) hardly varied. The stability of ETP can be attributed to its dependence only on the latitude of the location (which influences the incident solar radiation) and the temperature, which experiences minimal changes in this region over the years, as shown in Table A1.

It is also noticeable that during periods of increased rainfall, the green bars (representing the deficit) tend to decrease, while the light blue area (indicating excess) tends to increase. Thus, water storage ends up increasing as well. However, when the opposite occurs, the soil loses its water storage capacity, which can be recovered in subsequent rainfalls.

Table A1. Statistical analysis of the average monthly and annual water balance variables.

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
MEAN T (°C)	MEAN	9,9	10,8	13,4	15,1	18,4	22,3	24,7	25,1	22,4	18,6	13,6	10,9	**17,1**
	MEDIAN	9,9	10,8	13,4	15,0	18,0	22,3	24,9	25,2	22,6	18,6	13,6	10,7	**17,1**
	MÁX	11,9	13,2	17,1	18,0	22,2	25,4	26,9	27,2	25,1	22,3	15,9	13,5	**18,1**
	MÍN	8,0	8,7	11,0	12,2	15,5	18,6	22,3	22,9	19,5	15,3	11,5	9,3	**15,8**
	STAND. DEV	1,0	1,3	1,2	1,5	1,5	1,5	1,1	1,1	1,2	1,6	1,1	1,0	**0,5**
MEAN ETP (mm)	MEAN	19,2	24,8	40,0	54,1	83,6	122,4	144,6	140,1	103,8	67,7	34,5	21,9	**856,7**
	MEDIAN	19,0	25,1	39,6	54,0	80,9	122,8	145,9	139,8	105,1	66,9	34,1	21,6	**857,0**
	MÁX	26,9	34,2	59,9	72,8	113,8	153,3	167,9	161,2	126,8	90,8	43,2	29,8	**915,3**
	MÍN	12,4	16,2	26,6	36,4	66,8	89,5	121,7	118,6	84,8	48,9	27,1	17,3	**796,6**
	STAND. DEV	3,6	5,1	6,4	9,0	11,0	14,6	11,4	10,9	9,3	9,1	4,5	3,4	**26,1**
MEAN P (mm)	MEAN	64,0	49,1	53,7	60,2	46,8	13,1	1,1	4,2	29,5	79,2	76,4	86,4	**563,5**
	MEDIAN	53,7	47,2	36,7	54,9	33,0	5,7	0,2	0,4	20,5	75,0	63,6	51,6	**532,4**
	MÁX	275,3	146,0	155,3	152,0	165,2	76,7	8,5	40,5	118,5	188,0	282,9	279,3	**1042,3**
	MÍN	0,3	0,8	0,0	1,6	0,1	0,0	0,0	0,0	0,0	5,2	5,3	7,9	**316,3**
	STAND. DEV	52,1	36,1	41,1	38,9	41,5	18,0	2,1	8,6	31,0	45,3	63,1	81,2	**178,2**
MEAN ETR (mm)	MEAN	18,9	22,5	35,9	50,8	65,5	49,1	17,3	8,0	29,2	54,1	19,8	20,8	**392,0**
	MEDIAN	18,8	25,1	37,8	50,1	67,3	42,6	14,6	4,8	21,0	60,6	31,6	21,0	**396,0**
	MÁX	26,9	34,2	45,1	72,8	91,2	88,8	53,0	52,1	100,5	83,4	43,2	29,8	**567,2**
	MÍN	12,4	-14,8	-16,7	36,4	44,8	22,1	4,8	1,2	0,2	5,3	-65,1	2,5	**263,4**
	STAND. DEV	3,9	9,1	10,7	8,7	11,8	19,7	9,9	9,7	28,3	19,0	31,6	5,0	**79,5**
MEAN DEFICIT (mm)	MEAN	0,3	2,2	4,1	3,3	18,1	73,3	127,4	132,1	74,6	13,6	14,7	1,1	**464,8**
	MEDIAN	0,0	0,0	0,0	0,5	12,5	75,4	127,8	132,5	81,4	0,0	0,0	0,0	**458,5**
	MÁX	7,4	37,6	56,2	20,4	48,3	122,5	148,0	157,5	121,1	75,2	97,6	22,0	**624,1**
	MÍN	0,0	0,0	0,0	0,0	0,0	8,2	73,8	77,6	0,0	0,0	0,0	0,0	**289,4**
	STAND. DEV	1,4	7,3	10,7	5,1	16,9	28,9	15,7	15,9	32,3	21,7	31,4	4,0	**92,0**
MEAN SURPLUS (mm)	MEAN	36,1	25,4	22,7	15,9	6,0	0,0	0,0	0,0	0,0	1,1	19,2	45,5	**171,9**
	MEDIAN	21,5	17,8	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	12,5	**131,4**
	MÁX	251,0	122,7	120,5	86,4	93,7	0,0	0,0	0,0	0,0	28,1	179,4	250,9	**475,1**
	MÍN	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	**8,9**
	STAND. DEV	51,3	31,1	34,1	22,9	18,5	0,0	0,0	0,0	0,0	5,1	42,8	68,9	**126,6**

When the deficit is positive, it indicates that actual evapotranspiration has exceeded precipitation, resulting in a loss of water through the soil, as is common in the summer months, characterized by a lack of rainfall (from May to September). On the other hand, the opposite happens with the excess, which occurs in the opposite period, when there is a recharge of water in the soil due to abundant rainfall and lower temperatures. However, when both are equal to zero, this indicates that there was neither recharge nor loss of water in the soil, i.e. the amount of rainfall was equal to the amount of evapotranspiration.

It can be seen that Herdade da Coitadinha is located in a very arid region. When we analyze the maximum and minimum deficit and excess, we realize that the maximum deficit values do not show values equal to zero, while the maximum excess values do. Furthermore, when we look at the minimums, we notice that in the deficit some of the minimum values are relatively high, while in the excess all the minimum values are equal to zero, i.e. the tendency is for excesses not to occur and deficits to occur in this area.

Figure A3 shows the average monthly water balance over 30 years, considering rainfall data, reference evapotranspiration and actual evapotranspiration for a maximum soil storage of

100mm. In this diagram, it is possible to identify the periods of deficit, excess and recharge of water in the soil throughout the year. According to the calculations made, actual evapotranspiration (ETR) generally coincides with reference evapotranspiration (ETP), except when ETP exceeds precipitation (P). In other words, when the wide red band (representing ETP) overlaps the green band (representing ETR), it indicates periods of water deficit.

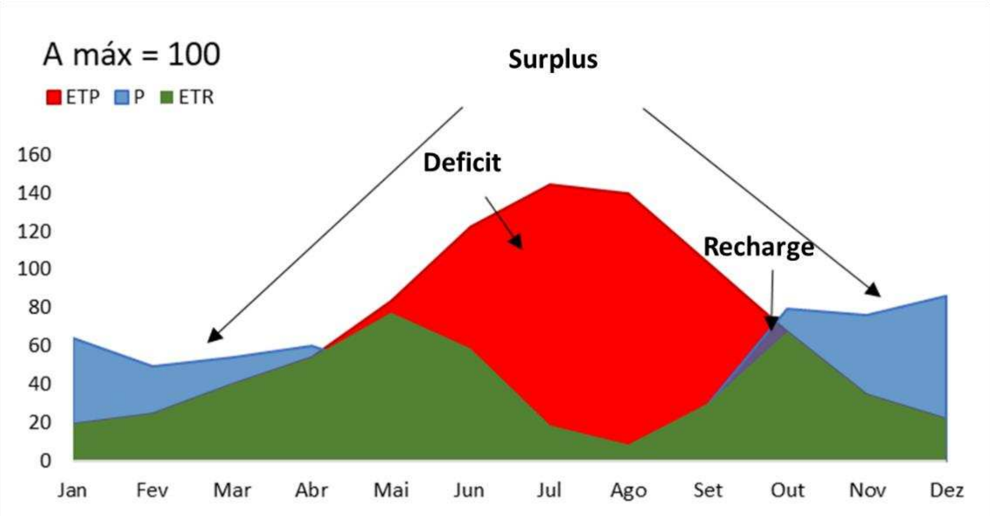


Figure A3. Average monthly water balance throughout the year for a maximum storage of 100mm.

Over the 30 years of data analysed, it is noteworthy that the average period of water recharge in the soil occurs during the autumn rains, between September and October, as evidenced in the diagram by the overlapping of the blue spot (representing precipitation) with the deficit area. After this phase, water storage in the soil reaches its maximum capacity. During the period from October to April, covering the winter rains, there is an excess of water in the soil.

Figure A4 illustrates the average monthly water balance under different soil water storage capacities, ranging from 100, 70, 50 and 25mm. Notably, the variations occurred exclusively in the storage conditions, keeping the representations of reference evapotranspiration and precipitation consistent in all the diagrams. Thus, the only difference observed was in actual evapotranspiration.

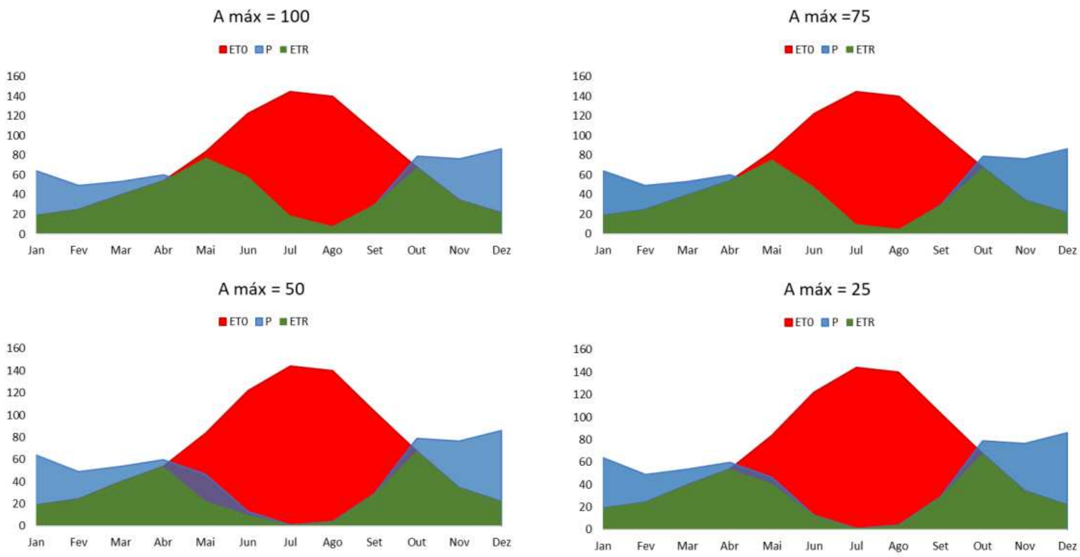


Figure A4. - Average monthly water balance for different soil water storage conditions.

During the periods between September and April, when there is recharge and later excess water in the soil, real evapotranspiration remains constant in all four storage conditions. However, when the period of scarce rainfall begins, in the months of May to August, the area representing the soil water deficit increases as the soil's water storage capacity is reduced.

When analysing the annual responses of actual evapotranspiration, excess and deficit in relation to the four storage conditions (Figure A5), it is clear that reducing this capacity results in a significant increase in deficit and excess, while actual evapotranspiration tends to decrease. This is because, as the soil's water capacity decreases, it becomes more sensitive to any change, be it flood or drought.

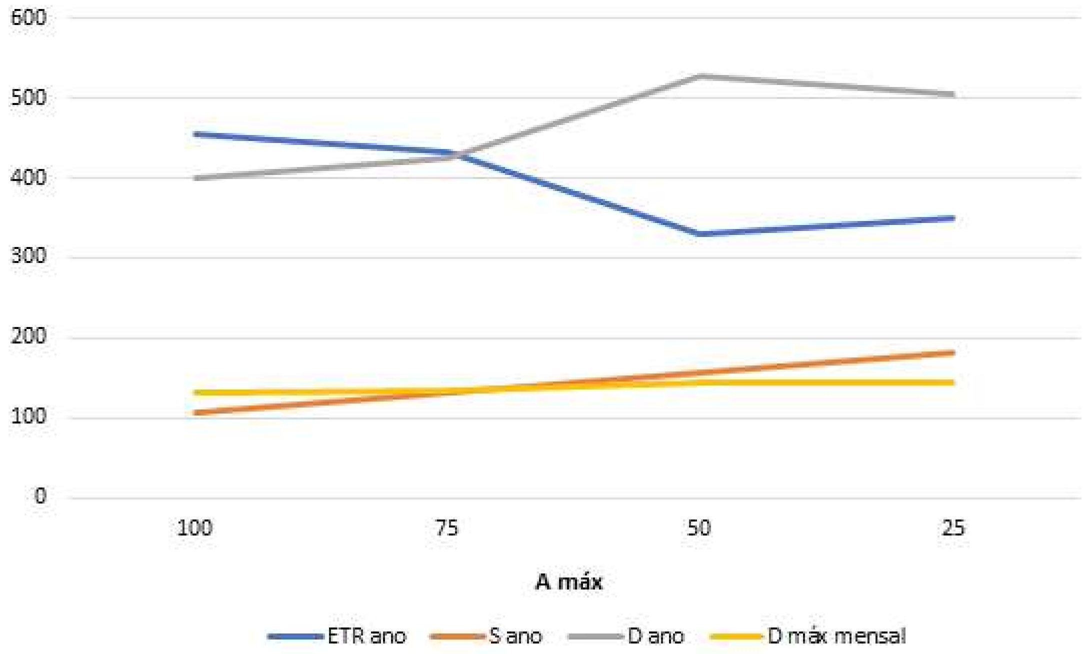


Figure A5. Annual response of ETR, S and D to different soil water storage conditions.

Table A2 complements the previous diagram by highlighting the months when the water deficit begins and ends, as well as quantifying it. It can be seen that in all cases the deficit lasts 5 months, from May to September. However, there is a noticeable increase in the maximum and accumulated deficit values when the water storage capacity is reduced.

Table A2. Annual water balance values for the different soil water storage conditions.

A máx	ETR year	S year	D year	D máx monthly	Length D	Start D	End D
100	456,2	107,3	400,6	131,7	5	May	September
75	431,8	131,7	425,0	134,5	5	May	September
50	330,1	156,6	526,7	143,7	5	May	September
25	351,1	181,6	505,7	143,6	5	May	September

2. Estimation of soil loss

The Universal Soil Loss Equation (USLE) was applied to estimate erosion rates in the study area. To do this, the available cartographic information on land use, land cover and soils was taken into account. In the first case, the land use and occupation classes were assigned the value of the USLE factor C, according to Zanella (2018) (Table A3). In the second case, correspondence was established between the classes represented cartographically according to the Portuguese classification (SROA) and the classes in the WRB legend (2015), and K-factor values were assigned according to Lima (2016) (Table A4). A single value of the USLE R-factor was considered in the calculations for the entire study area, taking into account its size. The estimation of the R factor followed that established by Figueiredo (2015).

Table A3. COS 2018 classes for the Herdade da Coitadinha area and their respective conversions to find the Cultural Factor (C) (adapted from Alves, 2018).

COS18n1_L	COS18n2_L	COS18n3_L	COS18n4_L	Correspondência	Fator C	Área (%)
Territórios artificializados	Equipamentos	Equipamentos culturais	Equipamentos culturais	***	1	0,23
Pastagens	Pastagens melhoradas e pastagens espontâneas	Pastagens melhoradas	Pastagens melhoradas	Pastagens permanentes	0,099	1,23
Agricultura	Culturas permanentes	Olivais	Olivais	Olivais	0,24	1,43
Matos	Matos	Matos	Matos	Matos densos	0,019	4,15
Massas de água superficiais	Massas de água interiores	Cursos de água	Cursos de água naturais	***	1	5,61
Superfícies agroflorestais (SAF)	Superfícies agroflorestais (SAF)	Superfícies agroflorestais (SAF)	SAF de azinheira	Florestas abertas de azinheira	0,048	38,36
Florestas	Florestas	Florestas de folhosas	Florestas de azinheira	Florestas de azinheira	0,0094	48,99

Note: *** refers to the values not found in (Alves, 2018) which were adopted as C = 1, since there is no vegetation cover for artificialized territories and watercourses.

Table A4. Soil type classes (WRB) and their respective correspondence cited in (Lima, 2016) to obtain the erosivity value (K).

WRB_Decodi	Correspondência	Fator K	Área (%)
Solos Incipientes - Aluviossolos Modernos, Não Calcários, de textura ligeira (inundável)	Fluvissolos ligeiro	0,0532	0,4
Solos Incipientes - Aluviossolos Modernos, Não Calcários, de textura pesada (inundável)	Fluvissolos pesado	0,0542	0,4
Solos Argiluviados Pouco Insaturados - Solos Mediterrâneos, Vermelhos ou Amarelos, de Materiais Não Calcários, Normais, de "rañas" ou depósitos afins (pedregoso)	Alissolos de Xisto (pedregoso) / Luvissolos de Xisto (pedregoso)	0,0068	0,8
Afloramento Rochoso de xistos ou grauvaques	Afloramento rochoso	0	2,0
Não Atribuído	Curso hídrico	0	7,0
Solos Argiluviados Pouco Insaturados - Solos Mediterrâneos, Vermelhos ou Amarelos, de Materiais Não Calcários, Normais, de "rañas" ou depósitos afins	Alissolos de Xisto / Luvissolos de Xisto	0,0183	20,4
Solos Incipientes - Litossolos dos Climas de Regime Xérico, de xistos ou grauvaques	Leptossolos Eutricos de Xisto	0,0208	68,8

The values of the topographic factor, LS, were obtained in a GIS environment, from the DEM, using the Wischmeier & Smith (1978) form in the raster calculator tool (Figure A6). The LS factor is an essential component in the universal soil loss equation and its revised version, which are used together to represent the topographic effect on soil erosion. The LS factor quantifies the impact of slope length and slope steepness on erosion. In short, longer and steeper slopes tend to increase the velocity of flowing water, increasing sediment transport capacity and, consequently, erosion.

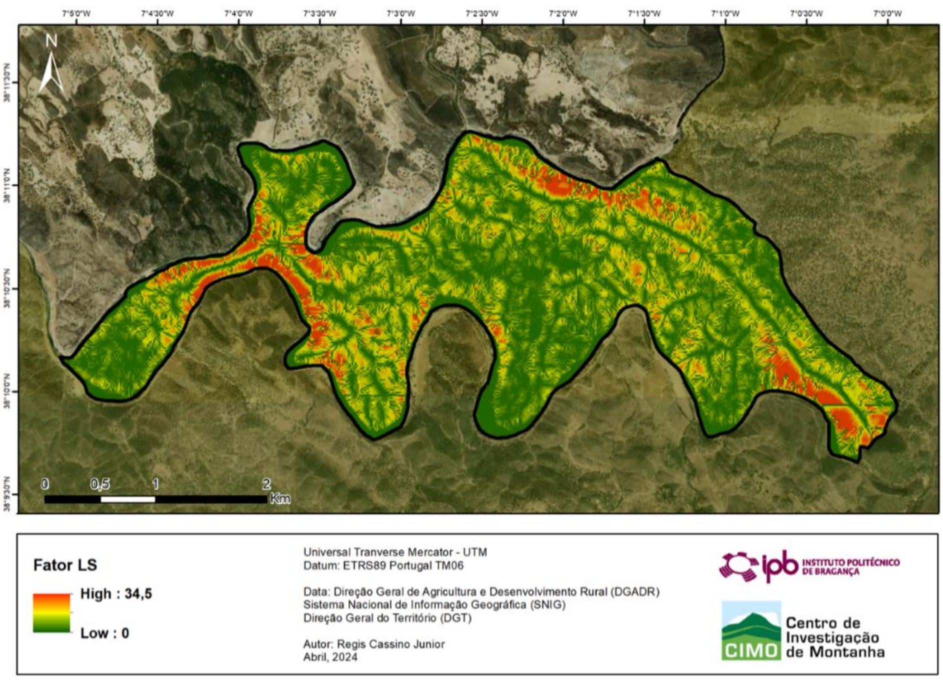


Figure A6. Map of the combination of slope length (L) and slope (S), forming the LS Factor.

The product of the R K LS factors produced the potential erosion map (Figure A7) and the R K LS C P product (with P assumed unitary) produced the current soil erosion map for the study area

(Figure A8). The results represented in the two maps correspond to annual soil loss rates, averaged over the long term, estimated by the model indicated. The statistics of the results (Table A5) obtained show a strong positive bias in the series of soil loss values, with medians much lower than the average. They also show that current erosion rates are below what is tolerable (2 tonnes/ha/year) in most of the study area.

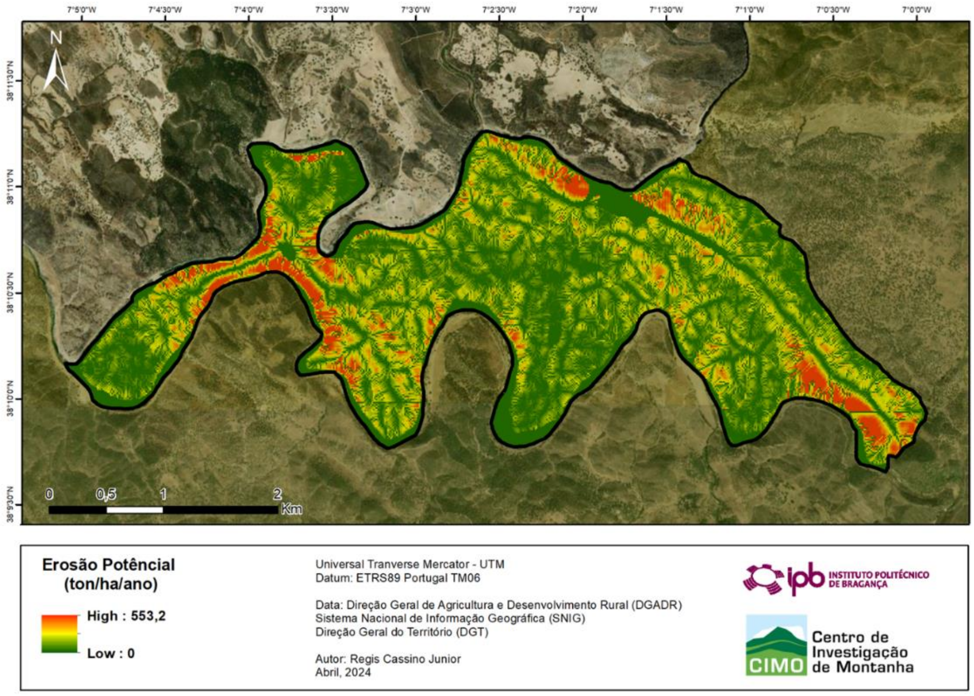


Figure A7. Potential erosion capacity map for Herdade da Coitadinha.

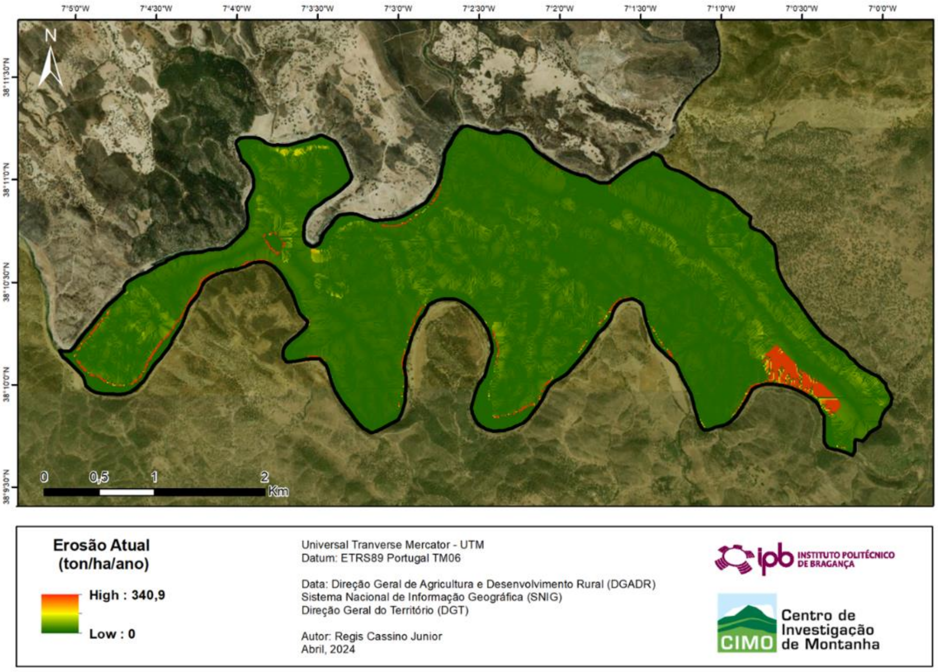


Figure A8. Actual erosion capacity map for Herdade da Coitadinha.

Table A5. Statistical analysis of Potential and Actual Erosion in the Herdade da Coitadinha area.

	Potential Erosion	Actual Erosion
Mean	47,26	2,37
Median	29,89	0,53
Max	553,19	340,90
Min	0	0
Standard deviation	57,71	11,65
< 2 ton/ha/year (%)	33,60	83,37