FOOD & BIODIVERSITY

Implementation of measures to promote biodiversity

# Examples in pilot farms with pastures and Montado in Portugal

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LIFE Food & Biodiversity Project
2019/2020

# CONTENT

# 1. INTRODUCTION

This publication presents the contributions resulting from the implementation of pilot measures promoting biodiversity carried out in mainland Portugal under the LIFE Food & Biodiversity project. In this project, MARETEC - Centro de Ciência e Tecnologia do Ambiente e do Mar do IST defined as its main objective the contribution to the conservation of cork oak forests, especially cork oak and holm oak. This is based on two main factors:

- The conservation of the montados and their biodiversity is a priority in our country, beyond its economic importance. The long-term sustainability of the Montado is currently threatened by the trend of decreasing stand density caused by mortality of adult trees, insufficient renewal (Almeida et al., 2016) and the planting of trees poorly adapted to the environment. The same activities that support multifunctional use and conservation of biodiversity in the Montado (e.g. grazing of livestock and tillage and shrub control with mobilisation) can become a threat if poorly managed (Pinto-Correia & Mascarenhas, 1999; Almeida et al. , 2016);
- IST (and its „spin-off" Terraprima - Environmental Services, www.terraprima.pt) has a high scientific and technical experience in the management of extensive livestock farming in the context of Montado with environmental objectives such as soil conservation, carbon sequestration and biodiversity conservation.

The selected measures benefit the maintenance or recovery of biodiversity and soil conservation on farms with animal production on plots with sown pasture and Montado areas.

All these estates were technically monitored and evaluated in relation to biodiversity performance, the state of the trees - in particular the cork oaks (*Quercus suber*) - and the soil. The measures proposed and selected in dialogue with the owners, and in some cases with the companies from which they are important suppliers, have been implemented and are integrated into the two pillars of an agriculture favourable to biodiversity (Biodiversity Management and Very Good Agricultural Practices for the Promotion of Biodiversity) and the indirect measures associated with these two pillars (Figure 1).

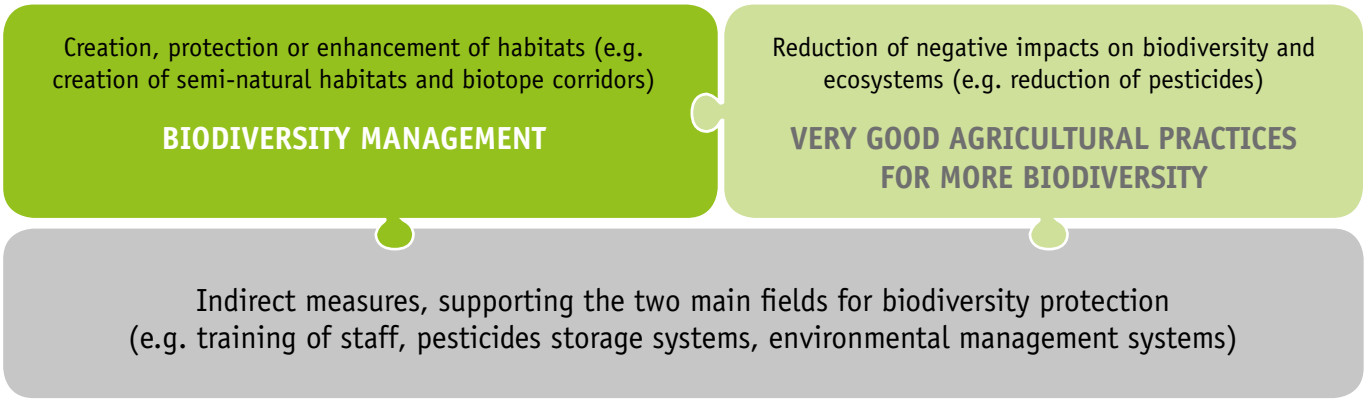


Figure 1 – The two main pillars of biodiversity-friendly agriculture: Biodiversity Management and Very Good Agricultural Practices. The indirect measures associated with these two pillars may also be particularly important.

This publication is aimed at decision-makers responsible for the design, development of food products and supply chain management (Figure 2), as well as for technicians who assess the implementation of quality criteria associated with agricultural production. The aim is to share the benefits and challenges related to the measures implemented so that they can be adopted effectively and efficiently, maximizing the positive effect on biodiversity.

Thus, a considerable part of the information in this publication comes from the sharing of practical experience of the farm managers where the measures were implemented and the consultants who supported this implementation. Where available, and for the purposes of scientific scrutiny, reference is made to scientific publications on the issues addressed.

Figure 2 - Typical products of the Cork Oak Forest (© Terraprima).

# 2. THE PILOT PROJECTS

The LIFE Food & Biodiversity project published "Recommendations to improve biodiversity protection in policy and criteria of food standards and sourcing requirements of food companies and retailers" in 2017. These recommendations include a catalogue of measures to promote biodiversity, which farmers can implement to improve their biodiversity performance.

The project also produced a series of training materials for consultants, auditors and Brand and Product managers, which include Action Fact Sheets that cover in detail various measures in this catalogue[1]. Most of the measures listed in this document correspond to these Action Fact Sheets, which are an important complement to the document texts.

All the measures presented in the Recommendations have been tested over long periods and by different stakeholders, in which their benefit to biodiversity has been proven. In order to further increase knowledge on the effects of these measures at regional level, 18 of the recommended measures were adopted in pilot projects for specific agricultural production in Spain, Portugal, France and Germany.

[1] Available at https://www.business-biodiversity.eu/en/biodiversity-training.

The measures implemented on farms in Portugal correspond to six categories, covering the promotion and/or conduction of natural regeneration of trees belonging to various native species, with particular emphasis on the cork oak (*Quercus suber*) and holm oak (*Quercus rotundifolia*) in the context of the Montado forest, as well as the diversification of the Montado undergrowth, the application of sowing techniques that do not require soil tillage, the control of undergrowth without soil tillage and the holistic management of pastures.

Figure 3 illustrates the location of the farms. In all cases these are holdings in the context of Montado or Holm oak groves, under extensive grazing with cattle or sheep. About half of these farms are suppliers to retailers and others sell to intermediaries without their own brand or directly to the consumer.

In most cases the project supported financially and technically the implementation of the measures, but there were cases where the measures were implemented and/or had already been implemented a few years ago autonomously by the farms, thus serving the project and this publication as a vehicle for their dissemination (Table 1 and Table 2).

Table 1 – List of measures implemented in pilot projects in Portugal. The number of farms where each measure was implemented is indicated, as well as the Action Fact Sheets that the LIFE Food & Biodiversity project provides with useful information on these measures.

| Measure/pilot project | No. of farms | Action Fact Sheet |
|---|---|---|
| Planting and/or protection of trees | 10 | Planting and maintenance of solitary trees |
| No-tillage seeding | 3 | Reduced Tillage |
| Shrub control without mobilization | 3 | Mechanical weeding |
| Grazing Management Plant | 2 | Grazing management<br>Ecopastoral management plan |
| Diversification of under-covering of the Montado (various measures, including the ones above) | 1 | Previous sheets<br>Planting and management of hedgerows |

Figure 3 - Location of the project's pilot farms in mainland Portugal (marked with red pins).

Table 2 – Measures implemented in pilot projects in Portugal, indicating the farms and their location, entities involved and support given by the project (financing or dissemination).

| Exploration | Measure/pilot project | Location | Project support | Entidades Parceiras |
|---|---|---|---|---|
| Casa Agrícola Manuel Gil Ferreira | No-tillage seeding | Torrão (Alcácer do Sal) | Dissemination | ANSUB |
| ETAP - Empresa Turigense Agrícola e Pecuária | Planting and/or protection of trees | Terrugem e Vila Boim (Elvas) | Funding | ELIPEC e SONAE - Clube de Produtores Continente |
| Herdade da Torrejana | Planting and/or protection of trees | Alter do Chão (Alter do Chão) | Funding | Rural Consulting |
| Herdade de Camarate | Planting and/or protection of trees | Samora Correia (Benavente) | Funding[2] | RAPORAL e Intermarché - Programa Origens |
| Herdade de Lemos e Monte Ruivo | Planting and/or protection of trees | Caia, S. Pedro e Alcáçova (Elvas), S. Brás e S. Lourenço (Elvas) e S. Vicente e Ventosa (Elvas) | Funding | ELIPEC e SONAE/ Clube de Produtores Continente |
| Herdade do Azinhal | Grazing management Plant | Azinheira dos Barros (Grândola) | Dissemination | ANSUB |
| | Planting and/or protection of trees | | Funding | |
| | Shrub control without mobilization | | Dissemination | |
| Herdade do Freixo do Meio | Diversification of the undercover of the Montado | Foros de Vale de Figueira (Montemor-o-Novo) | Dissemination and funding (partial) | Sociedade Agrícola do Freixo do Meio |
| Herdade do Galoguizo | Planting and/or protection of trees | Galveias (Ponte de Sor) | Funding[3] | Carnes Miranda e Intermarché - Programa Origens |
| Herdade dos Grous | Planting and/or protection of trees | Albernoa (Beja) | Funding | Herdade dos Grous |
| Herdade de Maria de Lurdes Gonçalves | Planting and/or protection of trees | S. Brás e S. Lourenço (Elvas) e São Vicente e Ventosa (Elvas) | Funding | ELIPEC e SONAE/ Clube de Produtores Continente |
| Herdade de Santo António das Paredes | Shrub control without mobilization | Vaiamonte (Monforte) | Funding | Rural Consulting |
| | Planting and/or protection of trees | | Funding | |
| | No-tillage seeding | | Funding | |

The following section details the implementation of the various measures.

## 2.1. Planting and/or protection of trees

As explained in the Introduction, the survival of the Montado is threatened by high mortality of adult trees and insufficient renewal with young trees. Grazing with high stocking densities (number of livestock heads per hectare) makes it difficult to renew the montado, either by grazing and ingestion of small plants or by damage caused to the young trees (especially in the case of bovines).

Studies clearly show that the natural regeneration of the Montados and their health status can be affected by inappropriate grazing (e.g. through excessive stocking density, either on the whole farm or on plots at certain times of the year). A correlation has been observed between higher stocking densities and increased fragmentation of the Montado, as well as a correlation between higher sheep stocking densities and decreased spatial heterogeneity of the Montado (Almeida *et al.*, 2016). The damage caused by overgrazing will be related to this effect.

In terms of the appropriate stocking rate in the context of Montado, e.g. for cattle, even a reduced value such as 0.3 LU/ha[4] may have a negative effect, and for sheep the limit may be around 1.2 LU/ha (Almeida *et al.*, 2016).

[2] Co-funded by ITMP Alimentar (Intermarché - Programa Origens).
[3] Co-funded by ITMP Alimentar (Intermarché - Programa Origens).
[4] Abbreviation for „Livestock Unit". A Livestock Unit is a unit that aggregates animals of various species and ages through estimated coefficients taking into account the basic nutritional or feeding needs of each species. As a reference, 1 LU corresponds to what an adult dairy cow, producing three thousand litres of milk per year, will consume, in terms of pasture, without additional concentrated feed (Eurostat, 2020).

This measure therefore aims to encourage the regeneration of the cork oak forest by planting new cork oaks and holm oaks and by protecting them (and the existing regeneration) from herbivory by placing artificial protective structures on young trees. In the case of Herdade do Freixo do Meio, pruning for the formation and management of adult trees was also carried out.

### 2.1.1. Implementation

Planting was chosen as an alternative to acorn densification as the experience of the project team indicated that, although the latter is cheaper, the germination and recruitment rate may be low[5].

In March 2020, 170 cork oak seedlings from 9 months to one year old were planted in Herdade de Camarate and Herdade do Galoguizo and protectors were placed around them (and in existing seedlings from natural regeneration). 320 protectors were also placed on 8 other farms between November 2019 and April 2020[6]. The "thorny bush" model was used (Figure 4), given the information from several producers that this model is the most suitable, as sun-mesh protectors do not resist boars and are less resistant to livestock.

Figure 4 - Illustration of the effect of the „thorny bush" type protectors against herbivory by livestock (image on the right extracted from https://protectorcactusworld.com/pt/protetor-cactus-sebes-espinhosas-cactus/).

The plantation started with the opening of 4 cavities (about 1 m x 1 m) per hectare in areas with little or no natural regeneration, near adult trees[7]. In these cavities, a "niche" was created with a hoe where the seedlings were placed and then surrounded by soil. As for the protection of natural regeneration, the plants to protect were previously marked in a visible way. Subsequently, the protectors (composed of three iron sticks and a 1.20 m x 1 m net panel with thorns) were distributed over the plots and were applied (Figure 5).

After planting, the seedlings were watered in order to increase the probability of survival of the plant.

[5] However, it is worth mentioning the experience of some actors in this project that when the acorn is sown together with a species from the same succession series of the Montado (such as the Strawberry Tree, Arbutus unedo), the success rate of the sowing is higher than when it is sown alone. There is also the perception that if germination is successful, and if they are protected, seed plants are more likely to survive (perhaps because they form the root on site and can therefore be more successful at capturing water than those which are planted).
[6] Part of the protectors placed in the Camarate and Galoguizo farms was acquired by ITMP Alimentar, S. A./Intermarché.
[7] Empirically, it is observed that cork oaks planted in shaded areas (namely in the shaded area of other trees) have a higher survival rate. The question arises as to whether this is the result of areas with greater direct sun exposure being subject to greater water stress and a higher rate of organic matter mineralisation.

Figure 5 - Planting and application of the "thorny bush" type protectors in the protection of plants against herbivory by livestock.

## 2.1.2. Benefits and experiences

The benefits of implementing the action observed on farms are several. The protectors effectively protect the seedlings due to their deterrent effect of herbivory, allowing an easier compatibility of the livestock with natural regeneration. They are also compatible with pruning. This leads to greater regeneration of the trees, with multiple benefits:

- Use of solar radiation by the trees and increased land cover resulting from increased plant cover, with the following positive effects:
  - Shading by the canopy plays a very important role in maintaining a "living" soil: litter provides organic matter to the soil and helps maintain its moisture; shading reinforces this effect and also helps maintain the moisture and temperatures appropriate to the metabolism of microorganisms; animals that take refuge in the shade also leave some inputs of nutrients;
  - Lower water losses in the soil due to evaporation and perspiration and reduced soil temperature (which also favours life in the soil);
  - Shrub control (due to increased overshadowing).
- Benefits for the age structure of the stands, safeguarding the replacement of adult trees in the montado whenever there are losses due to biotic and/or abiotic factors;
- Promotion of abiotic conditions conducive to a greater diversity of habitats, favouring the resilience of the system to rapid variations in atmospheric conditions and climate change. This greater diversity also has a positive effect on biodiversity (both at and above ground level), as distinct plants establish relationships with distinct species and provide more varied and more distributed nutrients over time;

- Creation of conditions that allow the development and maintenance of undercover, very important for the incorporation of organic matter in the soil, benefiting fertility;
- Decreased stress on young trees (resulting from trampling and mechanical pressure from livestock), given the physical barrier effect of the protector.

The protectors are easy and quick to apply and easy to handle, adjustable to various heights depending on the desired protection. They can also be reused in various situations because they are durable and easy to assemble and disassemble.

The main obstacles to the implementation of the action are the following:

- Difficulty in finding available labour, given the low value paid for this service[8];
- Unit cost;
- Long-term return on investment not directly visible;
- Low availability of technicians with adequate knowledge and experience for pruning operations;
- In some cases, reduced natural regeneration.

The implementation of this action took place about 6 months before the end of the project, and it is therefore difficult to assess its success in this particular case, in particular of the plantations (replanting will be made in the two years following the project). The placement of the protectors was successful and their effectiveness against herbivory could be observed.

### 2.1.3. Economic and productivity costs and benefits

The installation of "thorny bush"-style protectors is an efficient option for plant protection, but it is clearly more expensive than acorn densification, and has a higher cost per plant. Each protective structure costs 11.64 € (value without VAT), with the resulting cost of 46.56 €/ha (application of 4 protectors/ha).

Even taking into account that protectors can be reused, the investment is significant and protectors are captive for several years. They also have a higher labour cost in the installation. They can be used where the option of acorn densification is not possible.

A planting service equivalent to the one carried out in the project can cost around 15 €/ha and 240 €/day of technical assistance (to which 6.50 €/ha should be added if the placement of the protectors is contracted). If the service of opening the cavities with a backhoe is rented, this has to be taken into account.

In return, and if the action is accompanied by correct pruning of the trees, the production of acorns of cork oak or holm oak (and the correct regeneration of the Montado in general) may generate an additional return, in the long term, of 60 € to 100 €/hectare.year (in the case of exploitation with "Montanheira" pigs[9]).

In Portugal's 2014-2020 Rural Development Programme (PDR 2020), specifically in Forestry Measures 8.1 (1, 2, 3, 4, 5), financial support for this measure was between 40% and 85% non-refundable. However, the scarcity of these funds was reported by participants in this project, resulting in difficulty of access to them.

### 2.1.4. Useful aspects for the assessment of the measure by auditors

At the end of each summer, auditors should assess the survival rate of the plants and verify the correct implementation of the protective structures by means of a simple survey. They should also check how many of these structures are kept on the ground effectively to protect the trees.

[8] This leads to the conclusion that, given the importance of this service for the conservation of the Montado, it should be better remunerated.
[9] Amount usually paid for the rental of Montado land for use with "Montanheira" pigs.

### 2.1.5. Lessons learned and recommendations

This measure is the simplest way to promote the regeneration of the Montado. Experience at Herdade do Azinhal indicates that, in very sparse or unregenerated Montados, the Stone Pine (*Pinus pinea*) can function as a pioneer species for the regeneration of the cork oak forest.

As the measure is a remediation of harmful agricultural practices (such as excessive stocking density, inadequate grazing management or tillage), it is legitimate to argue that priority should be given to changing these practices so that regeneration occurs naturally and with sufficient vigour.

The placement of three to four artificial protection structures per hectare per year on average is common practice in relatively healthy cork oak forests. In cases of montados with a very low rate of natural regeneration, the number of protection structures per hectare should be higher.

Planting should take place between November and March and be reinforced with replanting in the following years until the desired number of surviving plants is obtained. The success of the action should be promoted by correct planting and watering the seedlings in the first year (especially when out-of-season droughts or unusually long drought periods occur).

## 2.2. No-tillage seeding

Soil ecology plays a key role in its natural functions. In general, soil treatments with fertilizers or phytopharmaceuticals negatively affect biodiversity. Oxygen, UV radiation and heat reach the soil, especially in situations where it has been mobilised, creating furrows with severe rim effects on biodiversity. Humification processes, which occur naturally under anoxic conditions, can be impaired, and the natural pore system of the soil can be disrupted. Each treatment affects soil biological diversity to different degrees.

High biological activity improves the self-regulation of soil ecosystems and the decomposition of organic matter. Surface treatments, such as the application of green manure and no-tillage seeding, are generally less harmful than deep tillage and therefore have less impact on soil biodiversity, such as earthworms, spiders and beetles. These small invertebrates, which form the basis of the soil trophic networks, also benefit from conservation-oriented soil preparation (Farooq and Kadambot 2015) and no tillage of the topsoil (0 to 30 cm).

In terms of other natural resources, no-tillage seeding, avoiding soil erosion, is crucial for improving water quality, since the loss of organic matter and the diffusion of phytochemicals are reduced. Improving water quality increases species diversity and the number of individuals. Soil fertility is recovered and carbon sequestration is increased. Maintenance of crop residues increases the number of species present and the number of individuals, both in terms of microorganisms and fauna, as these residues provide shelter and food for wildlife.

This technique is one of the applications of conservation agriculture, which consists of a set of practices that allow the management of agricultural soil with the least possible change in its composition, structure and natural biodiversity. The three principles of conservation agriculture are: minimum mechanical disturbance of the soil through the direct placement of seeds and/or fertilizers; permanent organic soil cover (at least 30%) with crop residues and/or cover crops; species diversification through varied crop sequences and associations involving at least three different crops[10].

[10] http://www.fao.org/conservation-agriculture/en/.

## 2.2.1. Implementation

This action consisted:

- Sowing, between October 2019 and January 2020, of fodder (oats + vetch and triticale + vetch) without soil tillage, over an area of 130 ha on parcels of three farms of the Casa Agrícola Manuel Gil Ferreira (CAMGF), replacing the fodder sowing done with conventional farming;
- In the application, in Herdade de Santo António da Paredes, of a mixture of grass and legume seed with no-tillage seeding (Figure 6), replacing the sowing of cereals (usually oats) usually made by tillage and using disc harrows (2/3 harrowing operations);
- In the sowing of meadows with no-tillage in Herdade do Freixo do Meio, using a mixture of seeds from biodiverse pastures rich in legumes, enriched with seeds of other native species (in more open areas).

Figure 6 - No-tillage seeding at Herdade de Santo António das Paredes.

A proper no-tillage seeder was used for fodder sowing at CAMGF. A 4 x 4 tractor was used to tow the seeder at Herdade de Santo António das Paredes. The sowing density was 35 kg/ha and the seed was placed at a maximum depth of 2 cm. In order to ensure the removal of excess dry matter and to allow the seeds to germinate, grazing with a high animal load was carried out before sowing (1 to 16 September 2019) and sowing was carried out on 16 September (the date on which the animals were removed).

## 2.2.2. Benefits and experiences

This action has a very positive cost/benefit ratio, given that:

- Considerable savings are made on mobilisation operations (operator working hours and fuel) by replacing four agricultural operations (two gradations, seed distribution and seed dressing) by one (no-tillage seeding);
- An improvement of the soil structure and its organic matter content is observed;
- In drought situations, the plots sown with this technique are the most resistant to water stress;

- There is an increase in organic matter content and a consequent increase in water retention capacity, an increase in fertility and a consequent decrease in the need to apply chemical fertilisers;
- The germination of the seed is faster, leading to a faster use of the green matter produced by grazing;
- When sowing pastures, mobilisation can lead to too deep a burial of existing seeds, which will not germinate. In such cases, it is smarter to sow selected seeds using no-tillage seeding to complement the existing seed bank.

The main obstacles were and are the following:

- The availability of equipment and qualified machine operators. At Herdade de Santo António das Paredes it was difficult to guarantee no-tillage seeding before the first rains, due to the small number of service providers with this offer of work;
- The size of the equipment, which prevents its use in some areas (namely in denser montados);
- The sowing period is much shorter (given the risk of weeds appearing, which would be eliminated by mobilisation);
- In Organic Farming there are obstacles to the use of herbicides, which are one of the alternatives to mobilisation for weed control;
- Many agricultural operators have used mobilisations throughout their entire lives and are not prone to implementing new techniques;
- Most farmers in the Mediterranean region generally apply traditional tillage with inversion of the soil to avoid possible soil compaction problems. No-tillage seeding can cause some difficulties in soil work and crop development, depending on the original soil conditions. Less aggressive tillage practices (such as conservation tillage) may be an alternative solution without losing the advantages of conservation agriculture;
- In some crop rotation systems, crops more susceptible to soil-borne diseases can be grown consecutively, and in such situations it may be useful to mobilise the soil to break the cycle of these diseases. In the conservation tillage system (which is between the no-tillage seeding and conventional tillage approaches in terms of intensity) an inversion of the soil could be carried out every 3-5 years;
- In the case of crops growing early, there may be problems of lack of nitrogen, which can be overcome by adding a nitrogen-rich fertiliser such as slurry, but this should only be done in small amounts (e.g. 15 kg) at the beginning of the crop cycle;
- In making the transition to low mobilisation systems, compaction could be a significant problem. On larger fields, a grazing control system could be used to prevent this;
- No-tillage seeding implies an increased need for herbicides. As chemical inputs carry risks of negative impacts on biodiversity, the implementation of cover crops, interline crops and other forms of control of spontaneous plants are of great importance. Machinery, training and, for some crops, specific research may be required.

### 2.2.3. Economic and productivity costs and benefits

The experience of the farmers associated with this project is that in the first years after sowing production will be lower than in subsequent years, but that savings in costs and time justify the investment.

The costs of raw materials, equipment and associated services are as follows:

- (In case of purchase) No-tillage seeder: 50,000 €;
- (In case of service rental) Operation: 75 €/ha;
- The cost of the herbicide varies with the product and concentration to be applied, but can range from 25 € to 40 €/ha (cost of product and application).

As for the investment required, Table 3 illustrates that no-tillage seeding is clearly more advantageous than conventional seeding.

Table 3 – Comparison of operating costs between conventional and no-tillage seeding.

| | Cost/ha | |
|---|---|---|
| **Operation or raw material** | **Conventional seeding** | **No-tillage seeding** |
| Soil preparation | 90 € | - |
| Herbicide[11] | - | 30 € |
| Fertilizer | 40 € | 40 € |
| Seed mixture | 90 € | 90 € |
| Sowing | - | 75 € |
| Seed distribution | 30 € | - |
| Seed spreading/ covering | 30 € | - |
| TOTAL | 280 € | 235 € |

Operation 7.4.1 (Soil Conservation - Seeding) provided public support for the implementation of this technique in PDR 2020.

## 2.2.4. Useful aspects for the assessment of the measure by auditors

For an assessment of the correct implementation of these actions in the context of an Agro-Environmental Standard, Label, Brand or Measure, auditors should assess productivity (productivity of pasture, cereal, dry matter/ha, etc.) and the absence of weeds.

## 2.2.5. Lessons learned and recommendations

The main conclusions, lessons learned and recommendations for the implementation of this action are the following:

- If the soil has some moisture, spontaneous plants (which will compete with the crop) may germinate. In this case, it must be guaranteed that these dry plants is removed by the date of the operation. In this case, the application of a herbicide may be advisable to avoid tillage. e. g. very low doses of glyphosate (2 L/ha)[12] may be applied. Alternatively, a flock of sheep may be used for grazing;
- A keyline[13] operation can be carried out to avoid compaction problems, although the experience of partner farmers does not report such problems;
- Herbicide should never be applied just before it rains, as the elimination of spontaneous plants can lead to the soil, being without vegetation, not being able to absorb the rain water, leading to the herbicide running directly into the water lines;
- It must be ensured that the sowing depth is appropriate to the seed used.

[11] To be used only under the conditions referred to in 3.2.2.
[12] The doses should be very low because this type of herbicide reaches all plants present in a non-selective way, reducing the food available for a large number of animal species (e.g. insects, birds, mammals, etc.) and may ultimately contribute to the collapse of trophic networks. However, some studies indicate that if soil is poorly mobilised, or in the absence of mobilisation, both the persistence of herbicides in the soil and the amounts disposed of are lower, due to higher microbiological activity in the topsoil and higher levels of adsorption of soil organic matter, respectively (Basch *et al.* 1995, Cuevas *et al.* 2001).
[13] A system that designs planting or sowing rows on gently sloping terrain, descending from the highest areas of water accumulation to the lowest areas of dryness in elevation. It is carried out with equipment designed to prevent the topsoil from turning over and to design small subsurface galleries. It allows the absorption of rainwater to be increased and the rainwater to be moved from places of accumulation (where it often causes erosion) to places where it would never naturally remain for long, in addition to decompressing the soil. It also allows the aeration of this zone of the soil and the penetration of the roots at a lower depth.

## 2.3. Shrub control without mobilization

The excessive accumulation of shrubs increases the risk of fire. Its regulation makes it possible to protect the montado from this risk, as well as to facilitate forestry operations (pruning, clearing, densification, etc.) and to reduce the water competition of the undergrowth with the trees in drought periods. In addition, this operation makes it possible to increase the forage area available to the animals and to ensure that the areas involved remain eligible for public support (avoiding them being considered as shrubby pasture, which is not eligible for the Basic Payment Scheme - BPS).

In national forest and woodland areas, it is usual to periodically carry out a control of shrubs, using methods such as harrowing, which mobilises the soil. These operations usually take place every 4 to 5 years and are destructive to the soil, causing the inversion of its horizons and the mineralization of organic matter accumulated during the non intervened period. In addition, widespread bush removal has negative impacts on fauna such as birds, reptiles and small mammals (which find shelter, food resources and nesting sites there), but also on soil fauna, which benefits from the overshadowing and protection of soil generated by shrubs.

These operations can also affect the root system of trees. Cork oaks have, in most cases, a superficial root system that expands beyond the canopy's projection, and any tillage will consequently affect the Montado. The results of the AGROREG project (www.agroreg.uevora.pt) indicate that most tree roots are in the first 30 cm of soil and are therefore destroyed by harrowing. This conditions their vegetative state and limits their capacity to absorb water during the summer period. This destruction can also serve as a "gateway" for root diseases.

As an alternative, the control of the undergrowth with a brushcutter or shredder implies an intervention on the surface and less damaging to the soil. Non-mobilisation has beneficial environmental and agronomic effects on soil by promoting soil protection, combating erosion and improving water regulation. It also reduces damage to tree roots[14].

This technique should typically take place from October to March (lower fire risk period). However, the extent of the area of intervention and the period of the year should be taken into account, given the importance of shrubs for the above-mentioned fauna. The protection of habitats relevant to nature conservation should be ensured.

Figure 7 - Shrub control with a brushcutter in Herdade de Santo António das Paredes.

[14] However, it must be safeguarded that bushes, especially when they provide small patches or shrub thickets in less productive or accessible areas (e.g. in rocky areas or next to ponds, path edges and stone walls), are an important refuge for fauna, including the Iberian Lynx (Lynx pardinus). In addition, they offer protection to cork oak and holm oak seedlings from summer drought, herbivory and trampling by large herbivores (cattle and wild ungulates) and improve their development conditions (shade, moisture and fertility), so they should not be eliminated indiscriminately. In these temporary areas there may be a significant increase in shrub cover and therefore a loss of production and pasture quality, which will have to be reversed when there is a sufficient number of new trees. Bushes may also compete with young trees for resources, so this is not a linear issue.

### 2.3.1. Implementation

Harrowing was replaced by an intervention with a brushcutter or shredder as a method of controlling scrubland in Herdade do Azinhal (170 ha), Herdade de Santo António das Paredes (Figure 7) (20 ha) and Herdade do Freixo do Meio (400 ha).

Taking into account the time of higher fire risk, the measure was implemented from October 2019 at Herdade do Azinhal and in December 2019 at Herdade de Santo António das Paredes. All the young trees coming from natural regeneration were marked with ribbons (to avoid their destruction by the machines), a small pruning was carried out on these trees and protectors of the "thorny bush" type were placed (see 2.1). Tractors with rubber wheels or caterpillars were used, depending on the slope of the ground and vegetation. The brushcutters can be knives, chains or hammers

### 2.3.2. Benefits and experiences

The benefits observed from the substitution of harrowing by the use of a brushcutter or shredder were the following:

- There was an increase in organic matter in the soil, and visually there are more mushrooms and less erosion;
- There is greater natural regeneration of the Montado. It is estimated that this is the result of avoiding the destruction of young plants (including their root system) by harrowing, and also that shredding increases the incorporation of organic matter into the soil. This regeneration leads to further overshadowing, which in turn results in less bush growth;
- The forage area available to the animals has increased.

The main obstacles to the implementation of the action were the following:

- At Herdade de Santo António das Paredes, the greatest difficulty was to make the operation compatible with the period of lower fire risk, also taking into account the few service providers available;
- Its high cost (harrowing is much less expensive);
- Its slowness, given the low operating speed required to implement it correctly;
- Trunks and branches may cause holes in the tires;
- The short duration of the benefits listed if the operation is not complemented with other actions (such as grazing with high animal load and/or soil corrections and fertilization).

### 2.3.3. Economic and productivity costs and benefits

The purchase of the shrub control service results in a financial investment of 40 € to 75 €/h and 3.5 hours of operation per ha every 4 or 5 years (between 140 € and 262.5 €/ha). At Herdade de Santo António das Paredes, a 2 meter shrub control equipment was rented and a service provider hired to operate, using its own tractor, at an estimated cost of 50 €/h. The operation took 1.5 hour/ha because the bush was not very developed and because the operational conditions were favourable, which resulted in a cost of 75 €/ha. In Herdade do Freixo do Meio, the cost was 50 €/h.

The cost of purchasing a brushcutter is estimated at between 2,500 €and 5,000 €, but the purchase of the service should be more feasible, except in areas where this service is not available. The measure may result in significant increases in organic matter in the soil.

In the RDP 2020 (Forestry Measures 8.1.1, 8.1.2, 8.1.3, 8.1.4 and 8.1.5), this measure was supported at 40% to 85% (non-repayable). In some regions, and depending on their Regional Forest Management Plan, farms should have a Forest Management Plan and each measure could not cost more than 40% of the total application budget.

### 2.3.4. Useful aspects for the assessment of the measure by auditors

The evaluation of the correct implementation of this measure in the context of a Standard, Label, Brand or Agro-Environmental Measure implies the inspection of the areas intervened in spring, and the work should typically take place from October to March (period of lower risk of fire). This inspection will be a simple check of the state of the soil and the size/development of the shrubby vegetation in the areas involved. The protection of habitats relevant to nature conservation should be checked, and the application of the measure should be recorded in the farm's cultivation register.

The action requires the auditor to have a forestry engineering or agronomic engineering background or a similar background.

### 2.3.5. Lessons learned and recommendations

The main lessons learned and recommendations concerning this action are the following:

- In the first years of this operation the undergrowth often appears to grow more vigorously, but in the following years this phenomenon is attenuated[15];
- The application of a fertilization contributes to a lower bush growth;
- The operation should not be performed when the shrub vegetation has great vegetative development, because the technical difficulty is great and the work is done very slowly, making the operation even more expensive;
- An equipment suitable for the existing shrubby vegetation should be used;
- Greater care should be taken to ensure compliance with occupational safety standards;
- As indicated above, the protection of habitats relevant to nature conservation should be checked in the planning of the intervention and potential negative effects on fauna should be taken into account, in particular taking into account the nesting season of birds;
- Herdade do Freixo do Meio reported that the use of clean cutting instruments (such as the mower) as an alternative to a wrecker allows a faster and more vigorous regeneration of vegetation, without the need for soil mobilization.

## 2.4. Grazing Management Plan

Pasture management practices aimed at providing ecosystem services (maintaining their potential for the production of sufficient good quality forage), such as holistic management and rotational grazing, as well as other related approaches, have been put in place to improve the quantity and quality of pastures (see Action Fact Sheet "Grazing Management Plan" of this project[16]). Several rotational grazing systems exist, involving the division of large grazing areas into smaller parcels (using physical or electric fences) and the rotation of livestock between them, according to a stocking density and grazing duration per parcel and periods of exclusion from grazing. These practices assume that by grazing in a confined space and in significant numbers, the animals remove a good part of the biomass, increasing the sun exposure; that they also accelerate the recycling of the nutrients through their droppings and, therefore, their availability for the growth of the new plants (effect amplified by the greater sun exposure); that, in addition, they encourage the germination of the seeds through their trampling and burying. That is, they assume that the animals have an effect of preparing the ground for the new growth phase of the plants.

In these practices, the close relationship between stocking density, time and the importance of pasture recovery time between grazing periods is addressed. These practices have the following characteristics:

- The frequency of grazing is based on the periods of recovery of the grass (and not on its ability to feed the animals, as in most situations), considering the periods of rapid and slow growth, characteristic and critical in semi-arid Mediterranean areas;

[15] A possible explanation is that in the first years after its shredding, the bush, having no competitors, grows significantly, but with the progressive incorporation of organic matter in the soil, other types of vegetation compete with the bush for resources, attenuating its growth.
[16] https://www.business-biodiversity.eu/en/biodiversity-training/advisors and https://www.business-biodiversity.eu/en/biodiversity-training/auditors.

- The management aims at providing ecosystem services such as soil and water erosion control, maintaining the potential of pasture for the production of sufficient quality forage;
- The adjustments in grazing are based on the daily growth rate of the plants, the performance of the livestock and/or the needs of wildlife;
- The stocking density is based on the ADA parameter (animals*day/hectare), adapted to the period of non-plant growth (plus a "time reserve" for the possibility of drought at the end of this growth period). This is a key point in Mediterranean habitats, given the seasonal growth (growth period restricted to some optimal periods in the year) and adaptation to climate change;
- Herbivory by wildlife can also have a positive effect on pastures, and this variable is incorporated into management plans;
- Management also addresses social, environmental and economic factors.

### 2.4.1. Implementation

The measure was applied in Herdade do Azinhal (which has been happening since 5 years ago in an area of 300 ha of pastures with 700 sheep) and in Herdade do Freixo do Meio. At Herdade do Azinhal, fixed fences, cisterns and water supply systems (flow-regulated troughs) were used. In Herdade do Freixo do Meio, smaller livestock parks and a higher animal rotation between parcels were used.

Figure 8 – Image of Holistic Management (http://www.aquinta.org/holistic-management).

### 2.4.2. Benefits and experiences

The observed benefits of implementing the action were as follows:

- In Herdade do Azinhal there is a higher productivity of pastures and greater natural regeneration of the Montado (the purchase of hay or straw bales for feeding the animals has been substantially reduced since the application of the technique). The experience reported in this farm is that, together with the longer recovery time of the grass, the shorter time of the herds in each plot leads to a lower consumption of fiber (such as tree branches) and a lower severity of damage to trees, especially in the case of bovines;
- At Herdade do Freixo do Meio, the use of smaller parcels resulted in lower grazing pressure and a reduction in the choice effect of the animal. That resulted in a more homogeneous "cutting" of vegetation by the herd, a reduction in trampling and compaction of the land (due to the shorter permanence time in each parcel) and an increase in the time available for pasture recovery.

The main obstacles to the implementation of the action were the following:

- The process is very slow, gradual and expensive. The fences are very expensive and have to be well sized, the number and location of water points have to be very well planned for the supply to various livestock parks and the livestock number has to be suitable for the logistics of the farm;
- The challenges to management are greater, as the use of smaller parcels and higher animal rotation between them also means higher labour costs in monitoring and driving the animals;
- Grass recovery periods are very long in winter and very short in spring, and it is difficult to have a livestock herd compatible with these conditions, as an appropriate herd size in spring may be too much for the winter;
- Electric fences are not effective for sheep because the wool is an insulator, and in the dry season the dry weather results in less electric conductivity of these fences.

### 2.4.3. Economic and productivity costs and benefits

The investments and associated benefits are as follows:

- The approximate cost of the fences is 4,000 €/km;
- Cost of a cistern with a supply system: around 7,000 €;
- Manpower required to bury the supply system;
- There is, however, a consensus that grassland productivity is higher.

In terms of public support, in the RDP 2020 there was support for operating investments such as the installation of fences, tanks and supply systems.

### 2.4.4. Useful aspects for the assessment of the measure by auditors

The existence of a management plan and/or grazing strategy with the selected grazing system must be verified. The stocking density shall be less than or equal to 1.4 LU/ha of forage area[17].

A correct implementation of this measure should be reflected in the following auditable results:

- Existence of a management plan and/or grazing strategy;
- Stocking rate less than or equal to 1.4 LU/ha of forage area;
- Absence of signs of compaction, erosion and soil degradation;
- Absence of signs of bush invasion in pastures;
- High soil fertility;
- Between autumn and spring (in summer the pasture is dry) there should be no overgrazing (i.e. the grass should be present) or undergrazing.

### 2.4.5. Lessons learned and recommendations

The main conclusions of the implementation of this action are the need for a large investment in planning with the use of farm maps and the need to associate the productive potential of the various plots. The following recommendations should be considered:

- The selection and implementation of a grazing plan and/or strategy may require the assistance of specialists;

[17] This figure is actually a simplification: at a given scale and/or over a given period of time, to achieve the objectives of this measure the stocking density may have to be much lower (or even higher). It should be understood as a maximum indicative value, which should be gauged for each plot and time period taking into account the state of the soil, pasture and ecosystems.

- Recording the location and movement of animals using imaging and communication technologies is an option for effective assessment and monitoring of pasture dynamics, herd spatial location and grazing pressure;
- The intensification of grazing, as well as the removal of grazing from a given area, can trigger rapid and heterogeneous successional changes, with unpredictable impacts on the composition of species;
- A significant effort should be made in training shepherds in these techniques, as they involve a substantial change in the way sheepherding is traditionally managed;
- The dynamics of pastures, the spatial location of animals and the grazing pressure should be assessed and monitored.

## 2.5. Diversification of the undercover of the Montado

This measure is being implemented at Herdade do Freixo do Meio and integrates several measures previously addressed in this publication (in which the experience of this farm was integrated), in addition to others addressed in detail in this section. It aims to diversify the undercover of the Montado, as well as to stimulate the growth of trees and shrubs, natural regeneration and fodder species (Figure 9).

Figure 9 – Aspect of the Montado at Herdade do Freixo do Meio (© Herdade do Freixo do Meio).

For the system to support the animal load in a sustainable way, reducing external inputs as much as possible, the gains in plant matter must be greater than consumption. Thus, first of all it is intended that the undercover should produce abundant vegetable matter for animal feed. It is also necessary that the presence of animals does not compromise the regeneration of stands. For this reason, secondly, the undercover is supposed to produce (or promote) natural regeneration and to protect it from damage caused by animals.

The health of adult trees is also essential for the stand to be productive and, for this reason, the soil and its fauna and mycoflora also play a fundamental role in the defence and nutrition of the trees.

Live hedges are very important elements of the landscape, providing habitats and refuges for beneficial and other species, functioning as ecological corridors and contributing to key ecosystem services such as controlling soil erosion and the run-off of excess fertiliser into water lines. Its multi-layered structure - soil, grass, shrubs and (if any) trees - enhances a great diversity of species. They also act as climate regulation and windbreaks (which benefit, for example, heat-dependent species such as lepidoptera). Many species also use hedges as a winter refuge, shelter, food (e.g. wild bees and other insects; hedges provide berries and other fruit in autumn), and as borders of their territory (e.g. as perches and singing sites for birds). They are thus habitat for many species, which feed and hunt in several strips, although most do not go beyond 30 m (and therefore reduce the need for pesticides in these areas).

### 2.5.1. Implementation

This measure is therefore composed of the following sub-measures:

- Use of brushcutters and/or mowers to perform "clean" (i.e. without shredding) and selective cuts in shrub species. In addition to the control of the fuel load (discussed in 2.3), this action is carried out here in the bushes with less vegetative vigor to stimulate their renewal;
- Seeding and planting of several native species such as blackthorn (*Prunus spinosa*), *Crataegus monogyna* ssp. *brevispina*, Plymouth pear (*Pyrus cordata*), elderberries (*Sambucus nigra*), buckthorns (*Frangula alnus*), oleasters (*Olea europaea sylvestris*), strawberry trees (*Arbutus unedo*), etc. This operation is carried out together with others, such as densification or other sowing operations. Fruits and seeds of different species are collected and dried or fermented and stored until they are ready for sowing. Where seed is not available or germination is difficult, this is enhanced by planting with species from the farm nursery or outside nurseries;
- Densification and protection of sown acorns by thorny native bushes. In areas with few adult trees, acorns are sown with other thorny species of the genera *Ulex*, *Crataegus* or *Prunus*;
- Protection of existing twigs with "thorny bush" type protectors (dealt with in 2.1);
- No-tillage sowing of pastures (dealt with in 2.2);
- Creation of smaller livestock parks, with higher rotation and shorter periods of permanence of herds in the same parcel (dealt with in 2.4);
- Planting "live hedges" next to fences.

### 2.5.2. Benefits and experiences

In addition to the benefits already mentioned in the previous texts, the following ones were registered:

- In addition to biodiversity reservoirs, live hedges can act as interruption bands in case of fire or provide food in times of lower availability (such as hedges with forage species such as ash - *Fraxinus excelsior* -, poplars - *Populus alba* - etc.). They can in part support livestock management in a context of planned grazing management, helping to compartmentalize pastures, but their management is also a major challenge;
- Sowing plants for biomass, their cutting and enmeshing also represents an additional difficulty, as it implies flat and unobstructed areas, which are not always available, sometimes requiring additional interventions.

### 2.5.3. Economic and productivity costs and benefits

In addition to the benefits and costs referred to in the previous texts, the planting of live hedges (a specific measure for this farm) has proved to be a low-cost and low-maintenance operation with clear benefits for biodiversity, and which is expected to contribute to the diversification of animal feed. However, it should be borne in mind that in the immediately adjacent space, there may be losses of income due to shading and competition of the hedges with crops for water and nutrients. Therefore a buffer strip (e.g. with flowering herbaceous species) should be maintained between hedges and crops (which, in turn, increases the quality of this habitat).

Hedges and other margins may also promote the proliferation of some weeds that may reach crops and harbour species that may constitute pests, such as aphids, which may have negative environmental consequences if they lead to increased use of pesticides and herbicides. They may also serve as a shelter for mice.

### 2.5.4. Useful aspects for the assessment of the measure by auditors

Live hedges must be at least 3 to 4 metres wide. They should be structures with a minimum of structural complexity (presence of shrubs and tree elements).

# 3. CONCLUSIONS

Table 4 illustrates, on a scale of 1 to 3, the costs, benefits to biodiversity and the complexity of the measures implemented based on the subjective assessment of the implementers of these measures (in the case of sowing without mobilisation and controlling shrubs without mobilisation, this assessment is made in relation to equivalent techniques with mobilisation). "Cost" refers to the monetary and time investment in the measure; "Biodiversity benefit" symbolizes the positive effect of the measure on biodiversity[18]; "Complexity" describes the amount of work related to implementing and maintaining the measure and its technical complexity. This ranking was given based on the subjective assessment of its implementers and the project team.

Table 4 – Classification of implemented measures in terms of cost and time, benefits to biodiversity and complexity.

| Measure | Cost and time | Benefit for biodiversity | Complexity |
|---|---|---|---|
| Planting and/or protection of trees | € | 🐝🐝 | ⚙ |
| No-tillage seeding (*vs.* tillage seeding) | € | 🐝 | ⚙⚙ |
| Shrub control without mobilization (*vs.* shrub control with mobilization) | €€ | 🐝 | ⚙⚙ |
| Planned grazing management | €€€ | 🐝🐝 | ⚙⚙⚙ |
| Diversification of the undercover of the Montado | €€€ | 🐝🐝🐝 | ⚙⚙⚙ |

Since these measures were implemented in the agricultural year 2019/2020 (which will end in September 2020), it is not possible to draw conclusions on their effect on biodiversity based on systematic and dedicated monitoring. To ensure greater success, the implementation of some measures will continue after the end of the project, such as the plantations (which will be reinforced in the next two agricultural years).

Nevertheless, it is clear that some measures have a very high cost/benefit ratio - in particular, actions to protect the natural regeneration and planting of Montado species. It was reported by all farms that "thorny bush"-style protectors proved very effective in protecting the regeneration of the Montado. Several measures were included in the RDP 2020 and it is expected that this funding will continue in the next EU funding framework.

It should be noted that the implementation of these measures results from a context (already referred to in the Introduction) of a decline in the Montado, with strong indications that inappropriate practices such as tillage, excessive stocking densities and inadequate grazing management have contributed significantly to it. Therefore, these measures should be encouraged by policy makers through instruments such as tax incentives and agri-environmental measures. One of these measures (promoting the regeneration of the Montado through the protection of trees or plantations) should therefore be understood as a remedial action which, in a context of systematic and consistent implementation of the remaining measures would not be (so) necessary.

Several of these farms are testing the Biodiversity Performance Tool (BPT), an online tool created by the project (http://www.biodiversity-performance.eu/) that supports the creation of a Biodiversity Action Plan for each farm, thus supporting the farmer in planning, adjusting and monitoring biodiversity measures. This tool also supports auditors in assessing the quality of the measures implemented.

[18] This benefit is understood here as compared to the "alternative" practice (i.e. seeding and shrub control without mobilisation vs. with mobilisation; planned management of grazing *vs.* unplanned management).

# 4. ACKNOWLEDGMENTS

The project thanks all farmers for their participation, especially where measures have been implemented without financial support from the project.

*"Although knowing that it will be a long-term investment, the placement of agroforestry protectors for the protection of natural regeneration at Herdade de Santo António das Paredes represents our commitment to the environment and the contribution to a balanced management of existing resources, not only economically but also environmentally. As for shrub control without mobilization, we also considered the environmental impact of to this operation, since it has several advantages over the traditional method of shrub control".*

**António Martelo**, Manager of Rural Consulting and of Herdades da Torrejana and Santo António das Paredes

**Pedro Silveira**, member of the Board of ANSUB (Association of Forest Producers of Vale do Sado) and manager of Herdade do Azinhal

*"I believe that fostering and/or conducting the natural regeneration of the Montado is the most practical way to reverse the loss of density and vitality of the Montado. I consider no-tillage sowing very important for soil conservation and adaptation to climate change.*

*From my 20 years of experience in implementing shrub control without mobilisation, this technique is fundamental in maintaining our traditional Montado systems and in adapting to climate change.*

*Planed Grazing Management, for me, means: "PLANNING, PLANNING; a lot of attention in the field, very constant presence in the field and capacity for interpretation".*

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## 6. THE LIFE FOOD & BIODIVERSITY PROJECT

The LIFE Food & Biodiversity Project ("Biodiversity in Standards and Labels for the Food Industry") aims at improving the biodiversity performance of standards and sourcing requirements within the food industry by:

a) Supporting standard-setting organisations to include efficient biodiversity criteria into existing schemes and encouraging food processing companies and retailers to include comprehensive biodiversity criteria in their supply guidelines;

b) Training advisors and certifiers of standards, as well as product and quality managers of companies;

c) Implementation of a cross-standard monitoring system on biodiversity.

The project has been endorsed as a "Core Initiative" of the Programme on Sustainable Food Systems of the 10-Year Framework of Programmes on Sustainable Consumption and Production (UNEP/FAO). It started in August 2016 and ends in September 2020.

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**Graphic design:** Brisk Design (July 2020).

**Credits of the photographs not indicated in them:** Cover and photo of António Martelo - Terraprima; photo of Pedro Silveira - himself.

Project beneficiaries:

Global Nature Fund

Bodensee Stiftung
Internationale Stiftung für Natur und Kultur

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PROGRAMA Origens
PORTUGAL SABE BEM

Organizations which own and/or manage the farms participating in the pilot projects:

ANSUB
Associação de Produtores Florestais do Vale do Sado

CARNES MIRANDA Lda.

casa agrícola manuel gil ferreira

Freixo do Meio

HERDADE DO AZINHAL

HERDADE DOS GROUS

RAPORAL

Rural CONSULTING
Gestão e Consultadoria Agrícola, Lda

Project funding entities:

EU LIFE Programme
LIFE15 GIE/DE/000737

A “Basic Initiative” of:

FOOD & BIODIVERSITY

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