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Conversion of Forest to Agro-Silvo-Pastoral System – Montado – in Mediterranean environments

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Key words: agriculture – forest – livestock - integration

Abstract: The Mediterranean environment regions are characterized by climate and soil specificities that justify low productive capacity for primary production when compared to other environments on earth. The Mediterranean forests are essentially formed by trees and shrubs. The shrubs are the perfect fuel to feed the forest fires that occur in a natural and cyclical manner in these environmental conditions. Therefore, the Mediterranean Systems of Agriculture have evolved to control the shrubs and the extensification of the systems because of low productivity. Sustainability is achieved by increase of productivity through improvement of the soil and irrigation. The application of these principles to the Mediterranean Forest resulted in the preservation of the trees, control of the shrubs and improvement of the pastures. Thus, the Mediterranean Agro-Silvo-Pastoral Systems have developed to recover and improve the soil. This desideratum is obtained by an efficient usage of Mediterranean Permanent Pastures. These, in turn, are only sustainable through proper grazing systems. All species of domestic animals are used in the process and because of the seasonal irregularity of the production of forage biomass, the Extensive Systems of Animal Production depend on the production and conservation of fodder crops. This paper intends to demonstrate how to recover a Mediterranean Forest farm, converting it into a Mediterranean Agro-Silvo-Pastoral System, known in Portugal as Montado. This is achieved using the Montado Crop Rotation and the Feeding Scheme of Extensive Systems of Animal Production, and needs investment in infrastructures for its implementation. A brief economic analysis is also elaborated, to conclude the technical, economic and environmental sustainability.

Introduction

The Mediterranean environment is characterized by very marked differences in the different seasons of the year. It is the only climate on the terrestrial globe in which it does not rain in Summer, which is dry, hot and long. On the other hand, the precipitation is quite irregular, both with respect to the intra-annual variation, or in the inter-annual variation. It is concluded, therefore, that the distinguishing characteristic of the Mediterranean climate is the hot, long and dry Summer, which is associated with low atmospheric humidity and very accentuated irregularity of precipitation. These unique climatic specificities are responsible for the impossibility of herbaceous plants to support the rigor of Summer, having evolved to overcome the dry season on the form of seeds (annual biological cycle plants). The soils are depleted and, more recently, one sees with apprehension that they are heading to desertification. The exposure to atmospheric agents after fires or the mobilizations of soils to which they are submitted cause combustion of the soil's Organic Matter (O.M.) and physical erosion, dragging nutrients and converting them into low productive capacity soils. Taking into account the irregular orography, we conclude that these regions are only able to support low capacity production systems, when compared to other climatic conditions. In these circumstances, it is pertinent to stress that the Mediterranean Environment is characterized by its *low primary productivity*. Thus, the Mediterranean Forest is formed essentially by tree plants (namely Quercinae) and shrubs (namely Cistacea) and the forest fires are a natural occurrence, in more or less extended cycles, because of the favourable combined conditions: presence of fuel (shrubs), high temperatures, low humidity and irregular winds that feed any simple ignition. The evolution of Mediterranean Agriculture Systems has always been focused on increasing the productive potential of the soil. It is based on the control of weeds / fuels to prevent fires and improve the productive capacity of soils, and increase productivity through irrigation. The possible application of these principles to the Mediterranean Forest resulted in the creation of agro-silvo-pastoral systems, which justify human intervention to counter natural imbalances. The stability of the systems depends on the adequate management and they are summarized in the preservation of the tree layer, control of the shrub layer and promotion / improvement of the herbaceous layer (annual grasses and leguminous plants of natural self-reseeding). Consequently, the key factor in the recovery process is the increase in the content of O.M. in the soil, which induces structural improvement, increases the content of nutrients (Soil Exchange Complex) and the storage of water. As the pasture is the most efficient way to

achieve this goal and the animal is the *sine qua non* condition for its maintenance, the objective of this paper is to demonstrate how an abandoned Mediterranean Forest farm can be recovered, converting it into an agro-silvo-pastoral Mediterranean system, which in Portugal known as Montado.

Methods and Study Site

● Characterization of Herdade da Caveira and Herdade da Ervideira, located in the municipality of Chamusca, district of Santarém. They are served by a road network that allows vehicles circulation.

- ✓ Caveira and Ervideira total area = 7141500 m2 = **714.15** ha
- ✓ Caveira area = 4818000 m2 = 481.80 ha
- ✓ Ervideira area = 2323500 m2 = 232.35 ha
- ✓ Caveira and Ervideira total perimeter = 11969.34 m = **11.97** Km
- ✓ Caveira total perimeter =12101.32 m = 12.101 Km
- ✓ Ervideira total perimeter =6578.84 m = 6.58 Km
- ✓ Agricultural area = **90.06** ha
- ✓ Agricultural area perimeter = **10.58** Km

These estates have sandy soils, consisting of more or less developed podzols, which are often associated with subsoil's drainage problems, typical of the Ribatejo's Miocene heath and have a modern sedimentation valley of about 90 ha. The morphology of the land allows the mechanization of all agronomic operations for the installation and exploitation of the stands. The sub-Mediterranean climate (SM) presents 2700 - 2800 h / year insolation; 12.5-16º C average yearly temperature; 700 mm total precipitation; 70-75 days with rain per year; 10-50 days with frost per year; 500 – 600 mm real evapotranspiration. They are forested by Cork-oak (*Quercus suber)* on 448.13 hectares, producing 23,398.4 @ (15Kg) of cork and an average density of 60 trees / ha; *Pinus pinaster* in 379.70 hectares, from natural regeneration and whose appearance occurs in areas where the cork oak is present; *Pinus pinea* in 15.83 hectares and Eucalyptus (*Eucalyptus globulus and Eucalyptus maidenii*) in 50 hectares.

● The methodology used to develop the recovery process consisted on implementing Montado Crop Rotation (Control of Shrubs→Forage→Pasture (n years)) (Potes and Babo, 2003). For the realization of the crop rotation, it is necessary to design a parceling plan adapted to the natural conditions of the farm, using GIS technologies for the purpose;

● The method used to calculate the Livestock Capacity of the farm was based on the implementation of the Extensive Livestock Feeding Scheme (Potes, 2008). The implementation of the scheme implies the management of grazing, for which it is necessary to individualize the paddocks (fences) and the parcels (parks) identified in the crop rotation, endow them with water supply (drinking points) and combine with animal management parks. The parcels in the valley (lowland) are used for the production of forage for conservation.

Results

● The survey of the natural conditions of the exploration, combined with the various cartographic elements, orthophotomaps and maps of cultural distribution resulted in the reparcelling plan to apply and implementing the Montado Crop Rotation, considering a cycle of 5 years, since the cleaning of the shrub area was recently carried out, Control of Shrubs has been suppressed and so pasture will last for 4 years (n = 4), for calculating feeding availability and infrastructure investment plan. Table 1 shows the distribution of paddocks by the Rotation parcels, with respective areas and excluded forest stands and the valley.

Table 1- Parceling for Montado Crop Rotation

Parks	Paddocks	Area, ha
Parcel 1	Padocks CA9/CA4/CA6/CA5	122.76
Parcel 2	Padocks CA3/E1/E10/E8/E7	111.83

Parcel 3	Padocks E2/E3/E4/E5/E6	131.92
Parcel 4	Padocks CA15/CA16/CA17/CA18/CA19	104.80
Parcel 5	Padocks CA20/CA21/CA22/CA23	103.34
TOTAL		574.66

● The Mixed Grazing Scheme was made from data collected in published works (Potes, 2011). For calculation of feeding availability and plan of investments in infrastructures was built Table 2. It is also possible to quantify the application of the risk coefficient and the evolution in the use of different livestock species according to the improvement process.

Table 2 – Food availability and Mixed Grazing Plan

Year	Biomass pro./year Ton****	<20% risk Ton	Montanheira Ton***	Goat Availability, Ton	Goat density, head*	Sheep availability, Ton	Sheep density, head**
0	574,658	459,726	64,8	394,93	541	0	0
1	697,416	557,933	97,2	460,73	541	65,80	0
2	809,249	647,399	129,6	517,80	541	122,87	0
3	1002,55	802,043	129,6	672,44	541	277,51	411
4	1224,64	979,716	129,6	850,11	541	455,18	674
5	1511,25	1209,00	129,6	1079,4	541	684,47	1014

*The Serpentina Breed goat needs approximately 730 Kg of D.M./per head/year.

** The Merino Breed sheep needs approximately 675 Kg of D.M./per head/year.

***In the first year Montanheira was calculated for 200 heads of Alentejano Breed pigs with 90 days duration (need of 3,6 Kg D.M./per day); second year of Montanheira for 300 heads and the rest of the years 400 heads.

****The biomass production (Dry Mater – D.M.) by crop intervention was calculated from Natural Pasture – 1.000 Kg D.M./ha/year; Forage - 2.000 Kg D.M./ha/year; Improved Pasture 1st year - 2.000 Kg D.M./ha/year; Improved Pasture 2nd year - 2.500 Kg D.M./ha/year; Improved Pasture 3rd year - 3.000 Kg D.M./ha/year; Improved Pasture 4th year - 3.500 Kg D.M./ha/year.

● The exploration of the various business areas that can potentially be carried out on the farm require basic investments, namely the fencing of the perimeters, creation of a water supply network for the various parcels and creation of livestock management parks.

Investment to be made – The implementation of the Agro-Silvo-Pastoral model in Herdade da Caveira and Herdade da Ervideira implies the initial creation of conditions, namely in what regards livestock farming. It is necessary to invest in 3 main items: placing fences, namely in the outer perimeter of the property and also to protect the agricultural zone and compartmentalize the different paddocks; make water available in the different areas of the farm, which implies the placement of pipes, pumping systems and reservoirs; creation of livestock management parks. A preliminary evaluation allowed us to reach an investment value in these items around 350.000,00 €.

Revenue – According to the preliminary analysis carried out, the farm has the potential to obtain revenue through exploitation: Forest – the forest production (cork) can be valued through a gross revenue calculation of 2.600@/year x 22,5€/@ = **58.500 €**/year**;** Agriculture - Valued by renting the valley (agricultural area). A value of 300 € / ha / year x 77 ha (utilizable area) = **23.100 €** / year**;** Livestock – Starting with goats and pigs (in extensive). In an initial cycle, revenues may come from Montanheira pigs, valued at 60 €/head and small ruminants (goats and sheep) valued by leasing 40 € /ha/year x 575 ha = **12.000 €** + **23.000 €** / 1st year.

Costs and results – The implementation of the Agro-Silvo-Pastoral System presented is based on the creation of a set of partnerships that allow the reduction of operating costs and risk mitigation. It is in this perspective that the exploration of the agricultural area is proposed to be carried out by a third party (the revenue being the lease) and that the livestock exploitation is also done in a partnership system (the entities that install the animals and are responsible for their exploration, or for paying for the fattening period on the holding). We therefore expect the following operating costs (**P**ersonnel **E**xpenses and **S**upplies and **E**xternal **S**ervices per year): Accounting – 2.400,00€; Office – 2.400,00€; Administrator Salary – 43.312,50 €; Employee salary – 13.860,00 €; Vehicle renting – 5.000,00€ ; Fuel – 2.940,00 €; Communications – 1.200,00 €; Repairs and Maintenance – 6.000,00€, making a total cost of **77.112,50 €**. The analysis makes possible to estimate Operational Result before Taxes (EBITDA) at **39.487,50 €.**

Revenue	122.600,00€
Staff costs	57.172,50€
Outsourced services	19.940,00€
EBITDA	39.487,50€
Investment depreciation	35.000,00€
EBIT	4.487,50€

Considering an investment depreciation of 10 years, one has an annual investment depreciation of 35.000,00 €. This means an Operational Result (EBIT) of **4.487,50€.**

Discussion (Conclusion / Implications)

Valuing only the products of Agro-Silvo-Pastoral exploration, the technical, economic and environmental sustainability of the ecosystem is verified (Potes, 2011);

The appreciation of the Environmental Services provided by the ecosystem (Potes, 2016) represents an economic and social (prevention of fire) added value and will contribute to the increase of its efficiency.

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