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In Common Existence of Decisionmaking Rules Concerning Planning Schedule of Operations

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Context

The modernisation of Spanish agriculture began in the sixties. This modernisation was reinforced in 1975 with democracy, then in 1987 with the entry of Spain in the EEC. It led to a double-oriented agriculture, with, on the one hand, a very intensive agriculture based on a high decrease in the number of farm workers, and on the other hand, a marginalised agriculture in the areas where natural conditions (soil fertility and relief) have not allowed this intensification to occur. The increased productivity of the latifundia system has now led to very efficient enterprises, providing the main part of the national production in agricultural and forest products. However, besides this intensive form of agriculture, there is a social concern for other types of agriculture more respectful of natural resources. Interest in the sustainability of production systems, is increasing, notably in sensitive areas.

The dehesa is a traditional agrosylvopastoral system, located in the southwest of the Iberian Peninsula. It is developed on poor soil, generally in mountainous regions. It consists of trees (oaks) producing acorns and forest products such as wood and cork, combined with herbaceous vegetation consisting of various species and domestic animals using these different forage resources (pigs, goats, ovines and bovines, all from local breeds). The tree is the key to the dehesa ecological system, it is the basis of all other producing activities (Vacher, 1984). The main tree species are the evergreen oak (quercus ilex rotundifolia) producing wood and acorns, and the cork oak (quercus suber) in regions with sufficient rainfall. Dehesa results from the transformation of the Mediterranean forest, under the effect of human practices. This has led to a complex ecological system, bringing about simultaneously good levels of diversified agricultural production, and protection and conservation of natural resources, thus allowing a sustainable development of the system (Campos Palacin, 1992, 1994; Roux, 1987). Formerly, and still recently, the dehesas relied on a large availability of workers, and low wages. As costs of labour force and products were changing, dehesas had been progressively neglected. The first change in the managerial practices affects tree maintenance, and therefore, the sustainability of the system.

The dehesa maintenance practices are traditionally of two kinds. First, grazing management consists of scrub clearing and controlled grazing in order to increase the availability of forage resources, and to prevent fire. Secondly, the tree maintenance includes pruning, clear cutting and tree replacement. Pruning has a positive impact on acorn production and also on cork and leafage production. Almost all of these operations rely on manual work, therefore they have been seriously affected by the reduction in the number of workers. The decrease in wood prices has also had a negative effect on pruning (Montoya, 1988).

The crisis which affects dehesas, did not have the same effect in all holdings (Roux, 1975):

- on the most fertile soils, evergreen oaks are uprooted and have given way to mechanised cereal cropping. Cork oaks remain, due to cork market sale.

- on the poorest soils, there are different types of evolution: pine and eucalyptus forest plantation for cellulose, commercial hunts, or more simply reverted land.

- on intermediate soils, the *dehesas* have been « modernised ». This means: new investments in order to substitute capital for labour (mechanisation, fences), development of more productive and less work-consuming livestock activities (bovines instead of ovines, improved breeds, intensive practices). (Campos Palacin, 1983)

Method and Results

We have conducted our study on a « modernised » *dehesa*, located in the Sierra Norte of Sevilla, in Andalusia. Data was obtained from different *dehesas* to build a model of a generic holding. The size of the *dehesa* modelled is 510 hectares, which corresponds to a medium to large holding. Within the mathematical programming framework, our methodological approach is two fold. First we built a model to understand the complexity and the diversity of the different types of production and factors involved in the system and their links. In this mathematical programming model, a farmer’s annual income is maximised. The idea is to determine the consequences in terms of production and management practices, of an optimisation on an individual and annual basis. Furthermore this model allows us to simulate the impacts of agricultural policy measures.

We then used a multi-objective programming method, in particular the NISE (Non Inferior Set Estimation) technique, to analyse the conditions to satisfy simultaneously the private objective of the dehesa owner, the social objective of maintaining regional employment and a long term sustainability objective. In our models, four levels of dehesa maintenance are considered, all the costs of maintenance operations being calculated on an annual basis. The different levels of maintenance have an influence on the farmers' income, in a negative way by adding costs, and in a positive way by adding production of acorns, leafage, and cork. The impact on long term conservation and regeneration of trees is not modelled.

From the first model, we found the following results:The level of maintenance chosen by the *dehesa* owner is the N1 level, the income reached in that case differed clearly from that which would allow a long term level of tree conservation and replacement, as shown in table 2.

Table 1: Main maintenance operations

	Maintenance levels			
Operations	None (N0)	Basic (N1)	Medium (N2)	Maximum (N3)
Cork harvest	+	+	+	+
Pruning	-	+	++	+++
Scrub clearing	-	+	++	+++
Cutting	-	-	+	++
Reforestation	-	-	+	++
Sprout protection	-	-	-	+
Controlled grazing	-	-	+	++

If we forced the model to shift from N0 to N3 maintenance level, we observed a change in the type of livestock production. In N0 and N1 levels, goats and also stags for hunting were present; in N2 and N3 ovine and bovine herds were found, pigs being raised at all levels. Considering the feed requirement constrictions and forage production calendars, the solutions of the model gave us a combination of several species of animals in all cases. The complementarity of the different livestock production regarding conversion of forage resources is another characteristic of the dehesa that prevents specialisation of production.

Table 2: Income and employment levels for different maintenance levels

	Optimal solution			
Maintenance	N0	**N1**	N2	N3
Annual income (pesetas)	2.284.393	7.668.772	5.419.133	-2.461.190
Employment (working days)	604	2.639	5.103	6.322

Besides this result, the model allowed us to evaluate the impact of agricultural policy on dehesa maintenance. We showed that the current farm policy is not well adapted to the specifications of the dehesa. Since the 1992' CAP reform, the dehesa is concerned with a large number of measures, related to bovine production, extensification and forest management. We included all the different measures that could benefit the dehesa in the model. It was not sufficient to move the optimum from the N1 maintenance level.The conflict between the private objective of maximising income and the public objective of maximising employment and forest maintenance appears clearly in table 2. It can be analysed through Multi-objective-programming (Romero, 1993; Romero and Reheman, 1986, 1993; Berbel Vecino, 1992). First, we determined the pay-off matrix that gave the levels of the solutions for the two objectives, optimised individually (points A and B). Using the NISE method, it was then possible to determine the trade-off between the two objectives and its consequences on the level of dehesa maintenance. We found two efficient solutions (C and D) between the two optima, and so obtained the solutions shown in table 3.

Table 3: NISE method results- efficient solutions

Solutions	A	C	D	B
Objective	Max. Income			Max. Employment
Level of maintenance	N1	N2	N2	N3
Income (psts)	7.668.772	4.405.374	-2.963.990	-8.863.810
Employment (days)	2.639	6.148	7.458	9.413

Considering the cost of moving from one solution to another, it clearly appeared that it was increasing as the level of employment increased. The main conclusion of this part of our study was that it was quite easy to move from solution A to solution C, the loss of income being at 932 pts per day of work (given that a day of work costs 5000 pts). It was much more costly in terms of income to reach solution B.It led to the idea that, with special subsidies, the dehesa owner could be encouraged to take on workers, and thus assure a good level of maintenance (level N2 in our model). The level of subsidy necessary to persuade the dehesa-owner to choose level N2 was determined to be equal to 3000 pts per day of work (60 % of the cost). This level may be lower, taking into account the fact that in our model we have not included long term positive effects of good maintenance.

The relevance of such a measure results from the following considerations:

- tree maintenance operations are carried out by seasonal workers paid per day of work
- labour costs stand for almost all the maintenance operations costs
- mechanised operations, such as scrub clearing, are much cheaper but not very suitable for poor soils.

Conclusion

The social concern for environment-friendly agricultural systems increases. Maintaining rural activity in marginalised area is now a clear objective of public policies. Besides, *dehesas* have long been considered an example of a complex ecological system allowing sustainable agricultural production and resource conservation. (Joffre et al., 1991).Even if the 1992 CAP reform has widely incorporated environmental considerations, its general application is not adapted to the specific needs of the *dehesa*. More appropriate could be special funds such as the rural employment program for Andalusia.We think that specific subsidies for maintenance operations should be implemented in order to encourage dehesa owners to preserve the sustainability of the system.

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