Sustainable management of Mediterranean forests in Spain

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A description of the salient features of Spanish Mediterranean forests and explanations justifying the application of forest management.

Sheep grazing under* Quercus ilex, *one of the most common multiple-use formations In Mediterranean Spain

The concept of *sustainable forest use* arose with the widespread organization of forests and the development of forestry as a discipline in the mid-nineteenth century. Before that time the relatively low demand for resources and the lack of extraction technology meant that forest resources were not generally threatened. In some cases, the close union between local people and their environment led to an understanding of and respect for the forests. It also encouraged the use of traditional forestry techniques, which had been developed empirically over the centuries and which were in effect "sustainable".

However, given the growing pressure placed on forest resources, these traditional methods no longer suffice. When the ecological foundations of such methods do not suit current conditions, new techniques for the exploration of natural resources must be developed. Only through the use of sustainable forest management can society's demand for goods and products be made compatible with the conservation of Mediterranean ecosystems.

Mediterranean forest characteristics

Mediterranean ecosystems have largely been shaped by long and intense human influences, as humans, domesticated animals and fire have created mosaics of distinct stands of thinly stocked (or shrub-like) forest, thickets and herbaceous/ woody pastures. To some extent, the exploitation of forest resources tends to balance these mosaics and individual stands, thereby ensuring their perpetuation and transformation; pastures are created, perpetuated and improved through the action of livestock, while forests are regenerated by thinning and the elimination of competing species.

In terms of taxonomy. Mediterranean forests are typically heterogeneous (even within a single stand) and show great climatic, geological, geomorphological and edaphic variety. Despite their relative stability, these forests are also characterized by a low resilience, or a limited capacity to respond to systemic changes. This renders them particularly vulnerable to soil degradation and erosion (often caused by indiscriminate extraction), which may be ultimately irreversible.

THE PURPOSE OF MEDITERRANEAN FORESTRY

Forest management has not kept pace with the recent diversification of forest functions or the development of stakeholders' conflicting interests. Past efforts to "dominate" forests for the production of economically viable products (primarily timber) must give way to practices based on a more holistic approach, including minimum intervention and a respect for nature. On the other hand, the economic aspects of forest management cannot be dismissed. Stock farmers defend free grazing with no limitations on stocking density and fenced-in spaces, while hunters seek to maintain large populations of wild animals. Animal protection groups, on the other hand, are opposed to hunting. Furthermore, certain forest management operations cannot be optimized in the same place simultaneously; for example, stocking density and the regeneration of the majority of tree species. The optimization of one particular use is invariably achieved at the expense of another use.

While it is generally agreed that, where possible, the sustainable exploitation of forests should be made compatible with a reinforced developmental process and the broad promotion of biodiversity, those responsible for Mediterranean forest management must acknowledge that:

- it is not realistic to abandon forests to the force of nature as a means of restoring and perpetuating their appearance and functionality;
- forest and land management are inseparable aspects of the same problem, namely environmental management;
- intervention is needed to protect and defend forests from the damage and dangers to which they are exposed;
- management decisions must guarantee the conservation of forest systems and, in many cases, should improve their functionality.

***Well-managed forests provide habitat for wild animals, thus ensuring both increased biological diversity and an additional source of revenue. In the photo:* Cervus elaphus**

MODELS FOR THE SUSTAINABLE MANAGEMENT OF MEDITERRANEAN FORESTS

In Spain, forest management has been practised in a more or less generalized, systematic manner since the end of the nineteenth century. Three forests have been chosen to illustrate the effects of forest management and exploitation over the last 100 years: one is populated with Corsican pine, the second with stone and maritime pine, and the third with cork oak.

As interpreted through changes in *stock* (the quantity of forest biomass, fundamentally wood, accumulated in forests) and *potential* (an a priori estimate of how much wood ought to (or could) be removed annually from the forest), over the last century the management of these forests has yielded very positive results. This is especially true where forestry has been more intensive, such as the "Los Palancares y Agregados" forest in Cuenca (Table 1), and in forests in which there has been less aid given to regeneration and more extensive forestry carried out, such as in the Llanillos, Arenas and Hoyos forests (Table 2). In the case of *El Robledal forest* in Malaga (Table 3), populated by cork oak *(Quercus suber)* and gall oak *(Quercus canariensis),* the degree of forestry intensification is less apparent because cork, rather than wood, is the object of exploitation. These results are similar to those in other studies of long-term forest management in Spain, and the data (Montero, Gómez and Ortega, 1991; Montero, Benito and Torres, 1991; Montero, Rojo and Hernández Fernández de Rojas, 1993; Rojo and Manuel, 1992; Gordo, Hernández and Finat, 1998; Jiménez, 1992; Manuel, Rojo and Montero, 1993; Hernández Fernández de Rojas and Montero, 1993).

The Los Palancares y Agregados forest *(Pinus nigra)* has been treated during the last 100

years by felling through successive uniform thinnings, with a cycle of 120 years and a regeneration period of 20 years. Incomplete natural regeneration has been assisted by means of small scarifications, and movements of earth have facilitated the installation and subsequent development of the regenerated material. Thinning is usually carried out when the regenerated material reaches 10 to 15 years of age and an average height of 3 to 4 m, leaving about 1 500 to 2 000 trees/ha. The next thinning is carried out between 25 and 35 years, and leaves between 1000 and 1200 trees/ha. The following thinning is performed at 45 to 55 years, leaving between 600 and 750 trees/ha. From that age on, improvement felling is carried out to eliminate malformed, forked or stag-headed trees. The last improvement felling, carried out at 75 to 85 years, brings the stand to the definitive density at which it will undergo the regeneration felling, which usually fluctuates between 250 and 350 trees/year.

TABLE 1. **Changes in the number of trees, stocks, potential and exploitation operations in "Los Palancares y Agregados" forest[1] - Cuenca**

[1] Species = *Pinus nigra;* total area = 4 848 ha. of which 4 561 ha populated.

Project	Period	No. of trees		Stocks *(m^3 with bark)*	Potential in the period *(m^3 with bark)*	Fellings in the period *(m^3 with bark)*
		at 10-20 cm Ø	at>20 cm Ø			
Organization	1896-1905	-	429 292	221 180	31 911	32 608
1st revision	1905-1915	-	466 776	226 275	34 286	34 286
2nd revision	1915-1925	-	511 890	268 440	44 376	44 062
Yearly plan	1925-1928	-	-	-	12 000	12 860
3rd revision	1928-1938	-	462 285	224 906	40 380	42 697
Yearly plan	1938-1941	-	-	-	5 862	6 867
4th revision	1941-1951	-	456 779	225 382	35 176	37 233
5th revision	1951-1960	605 613	521 625	327 899	44 318	40 630
Extension	1960-1965		-	-	52 350	59 292
6th revision	1966-1975	733 507	506 809	291 677	67 650	70 291
7th revision	1976-1985	748 481	493 555	256 375	64 620	71 184
8th revision	1986-1995	558 532	450 501	231 334	62 128	-
TOTAL					**432 929[2]**	**452010**

[2] The potential of the last decade is not included for the purpose of comparison with the total felling.

Table 1 shows that current stocks are slightly above the initial levels, both in terms of the number of larger trees and cubic metres with bark. The quantity of timber that has been

produced by the forest and extracted is double that of the initial stocks.

Intense extraction has not been matched by intense regeneration, as shown by the fact that the number of smaller trees and stocks have remained at almost the same level as the initial ones. Felling coincides almost exactly with what has been proposed in the management plans.

It is not an easy matter to summarize the salient features of forestry practice in the Llanillos-Parilla, Arenas and Hoyos forests *(Pinus pinea* and *P. pinaster),* since they contain species that offer highly diversified products (pine kernels, timber, fuelwood and resin). Technical experts have orientated forest management towards products and species with a greater market value; for example, they have favoured the kernel of the stone pine over the resin of the maritime pine.

The Llanillos-Parilla, Arenas and Hoyos forests are organized into fixed periodical grids, and have generally been felled by uniform successive harvesting, which leaves a residual stand that continues to bear fruit for 15 to 20 years afterwards. The natural regeneration of these species does not usually pose problems, provided the regenerating stages are protected from livestock.

TABLE 2. **Changes in the number of trees, volume and potential in the "Llanillos-Parilla", "Arenas" and "Hoyos" group of forests[1], Valladolid (1898-1996)**

[1] Species = *Pinus pinea* and *P. pinaster;* total area = 3 698 ha, of which 2 962 ha populated).

Project	Period	No. of trees		Stocks *(m^3 with bark)*	Potential in the period *(m^3 with bark)*
		at 10-20 cm Ø	at>20 cm Ø		
Llanillos-Parrilla forest (1 391 ha total, 1 928 ha populated)					
Organization	1898-1919	-	58 485	21 369	-
2nd revision	1920-1930	-	47 412	17 888	304
3rd revision	1930-1941	-	59 978	-	-
4th revision	1941-1952	-	67 385	-	-
5th revision	1952-1965	-	78 397	-	-
6th revision	1966-1981	-	120 741	-	-
7th revision	1982-1996	28 960	137 126	57 664	1 260
Arenas forest (1 905 ha total, 1 691 ha populated)					
Organization	1898-1919	-	105 260	36 096	-
2nd revision	1920-1930	-	118 188	41 835	301
3rd revision	1930-1941		139 522	-	-
4th revision	1941-1952	-	154 763	-	-

5th revision	1952-1965	-	161 742	-	-
6th revision	1966-1981	-	180 579	-	-
7th revision	1982-1996	51 852	194 170	84 189	1 666
Hoyos forest (402 ha total, 343 ha populated)					
Organization	1898-1919	-	22 414	8 899	-
2nd revision	1920-1930	-	26 446	11 638	301
3rd revision	1930-1941	-	28 950	-	-
4th revision	1941-1952	-	31 302	-	-
5th revision	1952-1965	-	30 811	-	-
6th revision	1966-1981	-	28 170	-	-
7th revision	1982-1996	8 919	36 768	18 028	398

These pine groves usually comprise three or four age classes, which generally coexist well if the upper layers are not too dense. In these stands the average production of pinecones fluctuates between 130 and 450 kg/ha per year and the production of wood is about 1 m^3/ha per year.

The development of these forests according to the form of management practised is demonstrated in Table 2. Stocks of trees greater than 20 cm in diameter for the three forests combined have doubled, while the number of smaller trees has increased by between 17 and 21 percent. Although the stock data are not complete, an increase in volume of 2 to 2.5 times may be observed. The data recorded concerning the relationship between the number of *Pinus pinea* and *P. pinaster* trees from the initial organization (1898) until the latest revision (1996) indicate an increase in stone pines and a corresponding reduction in maritime pines. With regard to the larger trees, the percentage of *P. pinea* has risen from 6 to 8 percent in the case of the Llanillos-Parilla forest and from 26 to 41 percent in the Arenas forest, remaining constant in the case of the Hoyos forest. Extensive forest management in these areas has balanced soil protection with the production of fruit and timber.

The forestry measures undertaken in the El Robledal forest *(Quercus suber)* to maximize the various forms of cork production are summarized below. It is essential to fence out livestock to ensure natural regeneration, or to use artificial regeneration in gaps or old areas of cork oak forest. In these stands (created by natural regeneration), the thinnings and first formation pruning must be carried out between 15 and 20 years of age, or when the trees have reached a height of 2.5 to 3 m and a diameter of 5 to 10 cm. From 800 to 1 000 trees/ha are left and formation pruning must reach between 1.25 and 1.5m.

The first thinning and second formation pruning are carried out some years before the first extraction of cork to allow the stand to respond to the thinning with a great growth in diameter (between 25 and 30 years). Between 450 and 500 trees/ha are left and formation pruning must reach from 2.5 to 3 m in height. Maintenance prunings must not exceed 30 percent of the branches of the crown of the tree, and must not be carried out during the three years before or after the removal of the cork layer. Regeneration felling is carried out by successive and

uniform harvests in which the trees producing good quality cork (between 25 and 35 trees/ha) usually remain in the forest for another 20 to 30 years. This allows the cork layer to be removed another two or three times and natural regeneration to be protected during the early years.

The results obtained with this management technique in the El Robledal forest are shown in Table 3. The larger trees (stripped of their cork layer) increased in number by 5.5 times between 1894 and 1990, while smaller trees (male cork) doubled and the total number of trees increased ninefold. According to those currently responsible for forest management, cork production tripled (insufficient information has been obtained to reconstruct a complete set of production figures).

A splendid example of* Pinus nigra *in Serrania de Cuenca, Spain

TABLE 3. **Changes in the number of trees in the "El Robledal" forest[1] - Malaga**

[1] Species = *Quercus suber* and *Q. canariensis* (area = 5 024 ha).

Project	Date	No. of trees			
		Male cork	Cork oak secondary	Total	Gall oak
Organization	1894	0	55 874	55 874	26 278
1st revision	1904	87 721	117 823	205 544	40 088
2nd revision	1914	135 239	139 295	274 534	37 298
3rd revision	-	-	-	-	-
4th revision	1936	184 963	269 275	454 238	48 642
5th revision	1944	139 908	276 287	416 195	40 251
6th revision	1955	161 498	283 222	444 720	35 187
7th revision	1963	56 357	309 182	365 539	31 981
8th revision	1971	69 180	324 762	393 942	29 768
9th revision	1981	109 871	318 537	428 408	27 764
10th revision	1990	189 767	308 426	498 193	52 002

CONCLUSION

In these cases, direct production from the forests (wood, pinecones or cork) has grown with the application of forest management. In no instance has any impoverishment of the soil been observed; production levels per hectare are the same or higher than when forestry operations first began, and the forests have more trees and are distributed more uniformly.

A clear relationship has been observed between the results obtained in each forest and the intensity of the management practices applied, and intensive forestry must always be practised where there are no irreversible ecological limitations on its use. Such intensification can be very successful when combined with a high degree of artificialization of the stand or by treating the forest with extreme care in order to maximize the production of wood without detriment to other aspects of the resource.

Nevertheless, in the face of a growing and varied demand for the indirect benefits of forests, the enormous advantages offered by extensive forestry in terms of sustainable exploitation should not be underestimated (Montero and Cañellas, 1998).

Pinus pinaster tapped for resin at an experimental stand managed by the Spanish Forest Service in Coca, Segovia

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