Invest Agrar: Sist Recur For (2006) Fuera de serie, 24-39

The Forest Map of Spain 1:200,000. Methodology and analysis of general results

J. Ruiz del Castillo y Navascués[1], C. López Leiva[2], J. I. García Viñas[2]*, J. M. Villares Muyo[2], P. Tostado Rivera[2] and C. García Rodríguez[3]

[1] *Ferraz, 24, 4.º. 28008 Madrid. Spain*
[2] *EUIT Forestal. Universidad Politécnica de Madrid. Ciudad Universitaria, s/n. 28040 Madrid. Spain*
[3] *Dirección General para la Biodiversidad. Ministerio de Medio Ambiente. Gran Vía de San Francisco, 4. 28005 Madrid. Spain*

Abstract

First of all, the main descriptive elements of vegetation used in the Spanish Forest Map on scale 1:200,000 (MFE2C) are put forward. Secondly, this paper includes an explanation of how plant cover maps are a supplementary tool for forest inventories in order to evaluate the actual state of vegetation. As an example, there is a description of characteristics of the current Spanish vegetation regarding the 4 descriptive elements of MFE2C: large climatic domains, structure, evolution level and dominant plant communities.

Key words: vegetation, climate, structure, evolutionary level, dominant plant communities.

Resumen

El Mapa Forestal de España escala 1:200.000. Metodología y análisis de resultados

En primer lugar se exponen los principales elementos descriptivos de la vegetación empleados en el Mapa Forestal de España a escala 1:200.000 (MFE2C). En segundo lugar se muestra cómo los mapas forestales son un instrumento de los inventarios para evaluar el estado de la vegetación. Como ejemplo, se muestran las características de la vegetación actual de España en relación a los 4 elementos descriptivos del Mapa Forestal de España 1:200.000: grandes ámbitos climáticos, estructura, nivel evolutivo y agrupaciones vegetales dominantes.

Palabras clave: vegetación, clima, estructura, nivel evolutivo, comunidades vegetales dominantes.

Introduction

The Forest Map of Spain on scale 1:200,000 (MF2C) typifies the plant cover of the entire continental and insular Spanish lands in an homogeneous way. A map on scale 1:1,000,000 has also been published as a synthesis of MF2C.

The project carried on an existent mapping tradition which began at the end of the 19th century. The National Forest Map Committee (*Comisión Nacional del Mapa Forestal*) was created in 1868 and dissolved 19 years later, leaving unfinished several maps and drafts of the provinces of Spain on 1:200,000 (Casals, 1996). Using collected data, a Forest Map of peninsular Spain was made in 1888 representing 20 tree species distribution on a scale 1:500,000, but unfortunately such map was almost completely destroyed in a fire. Mapping didn't continue until the early 20th century: in 1930, promoted by the Instituto Forestal de Investigaciones y Experiencias, the *Estudio sobre la Vegetación Forestal de la provincia de Cádiz* by Ceballos and and in 1933 the *Estudio sobre la Vegetación y la Flora Forestal de la provincia de Málaga* by Ceballos and Vicioso were carried out; those works continued in the provinces of Huelva, Ávila, and Soria, but they were not published. Some years later, *La Vegetación y Flora Forestal de las Islas Canarias occidentales* appeared (Ceballos y Ortuño, 1951) and afterwards the *Mapa Forestal de la provincia de Lérida* (Jordán de Urríes, 1954) was published. Those four projects included vegetation maps on a scale of 1:100,000, typifiying all forested patches by means of their main arboreous taxon; in the studies of Cádiz and Málaga most common tree mixtures were also repre-

* Corresponding author: juanignacio.garcia@upm.es
Received: 11-10-06; Accepted: 03-11-06.

sented. In all cases, non arboreous vegetation were generically indicated as «shrublands».

The first complete Forest Map of Spain, led by Ceballos, was published in 1966 on a scale 1:400,000. Forest patches were symbolized through their principal tree taxa, specifying if the occurrence was due to afforestation; as a result, 22 plant species for peninsular Spain and 15 for the Canary Islands were mapped; shrublands were generically grouped together into an unique type. The information from field surveys, carried out by F. Eng. Pardos, Úbeda and López Vallejo between 1962 and 1964, was directly sketched on provincial maps on scale 1:200,000 providing an excellent cartographic product, taking into account the limited material, economic and human resources available at that time, and brilliantly drawn by López González and López Fernández. Ceballos' Forest Map became since then a highly valuable reference to analyze the evolution of plant communities, being essential as well to truly know the natural and reforested distribution of main tree species in Spain.

Moving up to 1985, Dr A. Madrigal, subdirector of ICONA, and For. Eng. L. Berbiela, head of the *Servicio de Repoblación Forestal*, had the initiative to entrust Prof Dr J. Ruiz de la Torre with the design and planning of a new forest map. Since 1986 until 1998, Ruiz de la Torre also directed and coordinated field and office works of the MFE2C expert team in the Escuela de Ingenieros de Montes of Madrid, while map sheets were consecutively being published once finished all mapping tasks. The project was coordinated, supported and financed by the Área de Banco de Datos of the Dirección General para la Conservación de la Naturaleza (former ICONA).

Overall, the objective of the MF2C was to obtain an extensive collection of data, showing the current state of vegetation in Spain. Twenty years since the publication of the last Forest Map compelled the need for an update because of evident changes in the vegetation cover, mainly caused by several facts:

— Woodlands were no longer exploited for firewood and charcoal due to modern use of oil and natural gas as energy sources.

— The addition of new forest woodstands established by means of the Forest Plan (1939), as can be derived from Figure 1 (evolution of reforested area in Spain).

— The acute increase of rural depopulation.

— The abandonment of marginal agricultural lands at the end of the 70's.

— Changes in traditional ways of extensive livestock grazing

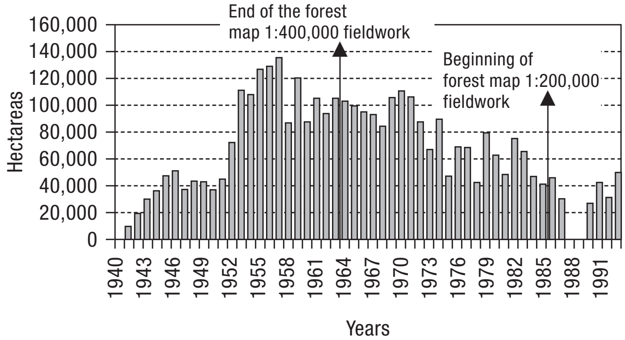

Figure 1. The evolution of the reforested area and the carrying out of forests mapping in Spain.

— The impact of agricultural mechanization involving the disappearance of small woodstands and thickets interspersed among crops.

— The growth of urban development in forested areas.

Selection of scale 1:200,000 was decided to achieve several objectives and needs: representation of types of plant covers dominated by tree species in small areas; characterization of non forested covers with a certain degree of detail; and the feasibility of finishing the whole work in a reasonable amount of time.

This paper put forward a brief outline of the methodology followed within the MF2C project along with the major characteristics of the Spanish vegetation regarding the considered parameters.

Description of vegetation in the MF2C

The MF2C uses an original system designed by Prof Ruiz de la Torre. It examines 4 types of components, enabling detailed descriptions of vegetation that are also easily accessible for a large number of scientists and technicians who may not be necessarily specialized on complex classification systems.

The environmental component

The MFE2C uses the concept of *Climatic-Structural Type* (CST). It involves a prevailing physiognomy determined by the most dynamically developed (most mature) plant cover that can occur with a stable balance with the regional climate and soil. The general framework for environmental component is therefore bioclimatic.

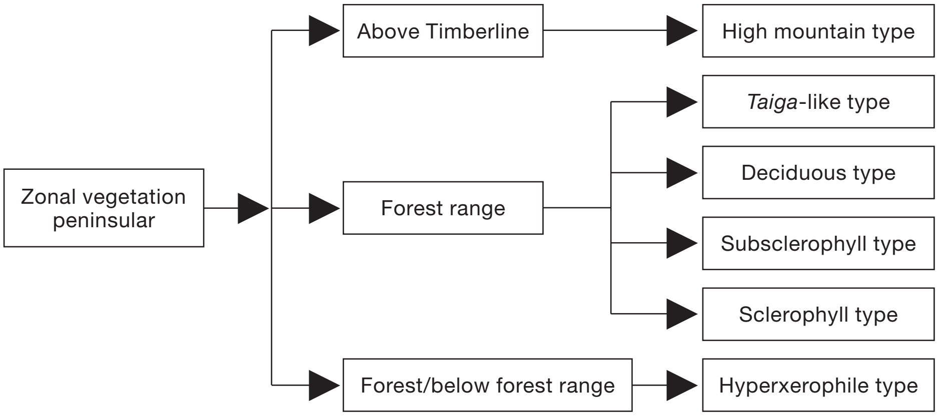

Figure 2. Outline of the zonal climatic-structural types of peninsular Spain and the Balearic Islands.

Zonal vegetation is essentially conditioned by climate. It belongs to several CTS: the Iberian peninsula and the Balearic Islands are made up of 6 zonal types (Fig. 2) and there are 5 zonal types in the Canary Islands (Fig. 4). An approach to their geographic distribution is shown in Figure 3. Their major traits are described below.

High Mountain Type or Above Timberline Belt (A). Arboreous vegetation has an evident latitudinal and altitudinal limit, as a response to a complex interaction of natural causes which can be defined following different approaches (Veijoa, 1998). The *timberline,* located in the highest mountain ranges, marks the beginning

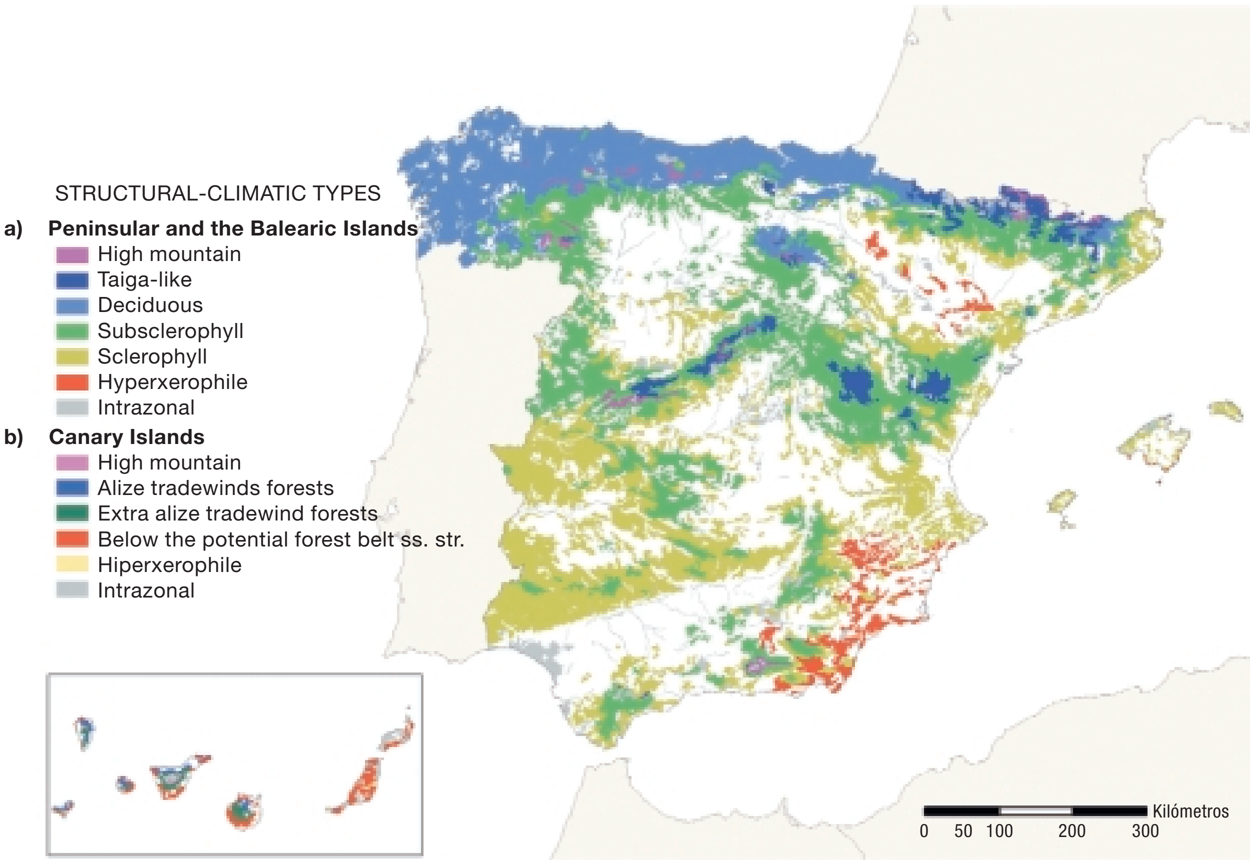

Figure 3. Distribution of the climatic-structural types according to data from MFE 1:1,000,000. Blank areas refer to agricultural lands.

of the generalized occurrence of high mountain vegetation. Nowadays, the exact altitudinal belt boundary may be not clearly delimited due to the alteration caused by ancestral grazing exploitation of most mountain areas and the lack of direct meteorological data. Moreover, there are differences among mountain ranges and comparing the exposure (sunny or shady hillslopes). In the Pyrenees, Montserrat (1990, 1992) locate it at (2,300) 2,500 m; Díaz *et al.* (1998) set it out at (1,700) 1,800 m in the Cantabrian mountains, as well as in Moncayo (Iberian Range) according to Villar (1990); and Allué (1996) deduced the altitude of (1,800) 2,100 m in the Central Range. Plant covers are dominated by microthermal and hygrophile species which constitute either scrubs or graminoid communities and, further uphill, semideserts and rocky deserts.

Taiga-like Type or Mountain Needleleaf Forests domain (T). Strictly speaking, *Taiga-like* refers to conifer forests in northern regions at sub-arctic latitudes, but it can be equivalently applied to needleleaf woodlands of the high mountain belts in middle latitudes, like in Spain. This type is located, when existing, immediately below the *High Mountain Type*. This characteristic conifer area in the Mediterranean region is so recognized by several authors such as Quezel (1982). It occupies cold climate areas with regular long periods of frost and cool summers, with no water shortage (Ruiz de la Torre, 1990). The growth period is longer than in the *High Mountain Type*, but it is too short and there are too many frosts for Deciduous angiospermae trees to dominate. Its width varies between (1,500) 1,600 and (2,300) 2,500 m in the Pyrenees (Montserrat, 1990, 1992); 1,500 and 2,100 m in the Central Range (Allué, 1996) and above (1,400) 1,500 m in the southern Iberian Range (López Leiva, 1995). Relatively microthermal and hygrophile species (mainly genera *Abies*, *Pinus* and in a lesser extent, *Juniperus* and *Taxus*) prevail in the arboreous plant covers.

Deciduous Type or Deciduous Forests domain (C). This belongs to mild or cold winter climates and warm or warm-hot summer thermic pattern with no water shortage (Ruiz de la Torre, 1990). The growth period is longer than for the *Taiga-like* and allows the predominance of deciduous angiospermae trees. It is spread throughout all northern regions with atlantic climate, although it is also interspersed in mediterranean Spain. Thus, the potential area is located along the Cantabrian range (below timberline) and in the whole litoral strip from Galicia to Navarra, therefore located between 0 and (1,700) 1,800 m (Díaz, 1998) and in central Pyrenees between (1,000) 1,200 and 1,600 m. Genera *Quercus*, *Fagus*, *Betula* and *Tilia* are dominant.

Subsclerophyll Type or Subsclerophyll (submediterranean) Forests domain (S). In climates with a cold or mild-cold winter and a warm summer, subdry or at least having a subdry period (Ruiz de la Torre, 1990) which lasts less than 3 months. Generally speaking, this type is found between 800 and 1,500 m in mediterranean Spain; in addition, there are scarce patches in the atlantic region, almost at sea level. Broadleaf semirigid, semideciduous or deciduous tree species dominate o co-dominate, like species of genera *Quercus*, *Acer* and some *Pinus* and *Juniperus*.

Sclerophyll Type or Sclerophyll Forests domain (E). In climates with mild to cold, wet to subdry winter and a hot, dry period of 3-5 months which includes the whole summer or it is centred in part of it (Ruiz de la Torre, 1990). It is located from sea level up to 800 (1,500) and more. The prevalence corresponds to evergreen tree species with small, hard leaves of genera *Quercus*, *Olea*, along with *Pinus* and *Juniperus*.

Hyperxerophile Type or Hyperxerophile Plant Covers domain (H). It occupies potential forested areas, but only at the transitional boundary towards places inside a non forest fringe, where tree species cannot constitute large woodstands due to arid climate conditions. It belongs to mild and cold regions, with drought during almost the entire year or periodical sequences of considerably dry years (Ruiz de la Torre, 1990). It is located from sea level up to 800 m. Currently, these areas undergo a considerable antropic degradation which, along with the abundance of interspersed special soil (salts and gypsum), makes the possibility of sparse arboreous covers occurrence still more difficult. Its most representative tree species belong to genera *Pinus*, *Tetraclinis* and *Juniperus*.

The Canary Islands are shared by 5 zonal types (Fig. 4).

High Mountain Type or Above Timberline Belt (S). Only present in Tenerife and La Palma. Its vegetation has a more arid physiognomy than the ones located immediately below. The thermic pattern is colder, with large temperature contrasts among seasons and between mornings and nights. Its width varies from 2,000-2,500 m up to the highest summits (Ruiz de la Torre, 1990). Plant covers are made up of several scrubs dominated by species of genera *Spartocytisus*, *Adenocarpus*, *Pterocephalus*, *Echium* etc. and the lychen *Griminia*.

Alize tradewinds forests Type (SA). Found in Gran Canaria, Tenerife, La Gomera, and El Hierro and loca-

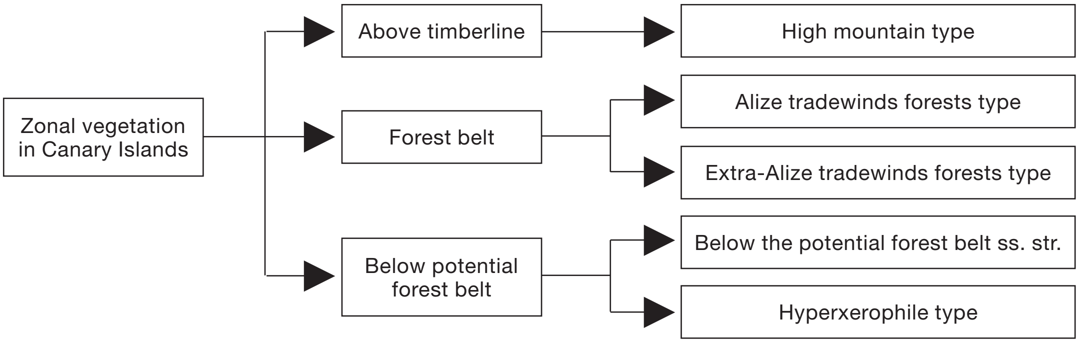

Figure 4. Diagram of the zonal climatic-structural types of Canary Islands.

ted between 500 and 1,500 m. It has a windward orientation towards the wet alize tradewinds (alisio) provoking extremely abundant fog. This is the area of the *laurisilva* and most of the *fayal-brezal*. Its dominant tree species belong to the genera *Laurus*, *Ocotea*, *Erica*, *Myrica* etc.

Extra Alize tradewinds forests Type (SE). Located in Gran Canaria, Tenerife, Gomera and El Hierro, in a wide altitudinal belt between 500 and 2,000 (2,500) m, to leeward to the alize tradewinds, therefore without condensations from its fogs. Most characteristic species belong to the genera *Pinus* and *Juniperus,* along with others which are less frequent, like *Olea*, *Pistacia*, *Phoenix*, *Dracaena* etc.

In the lower belt, outside the domain of potential forests, the CST can be distinguished between the following:

Below the potential forest belt sensu stricto *Type* (I). An arid climate prevails within this domain, with rainfalls between 150-250 mm, hot temperatures and an almost permanent dry period. It is located between sea level and about 500 m. Several scrub communities dominated by genera *Euphorbia*, *Senecio*, *Rumex*, *Hypericum* etc. occur.

Hyperxerophile Type (H). It represents the most acute dryness within the above mentioned type, with annual precipitations below 150 mm. The thermic pattern is hot. When present, it occupies a strip between 0 and 400 (500) m. Plant communities are basically very sparse scrubs, the most characteristic taxa being of genera *Launaea* and *Euphorbia.*

There is also a set of *intrazonal* vegetation types in areas where some local predominant soil features condition the composition, structure and physiognomy of the high specialized existing plant covers, either forested or non arboreous (Fig. 5): communities belonging to the *Glycohydrophile Type* (damp soils with non salty water in river banks, mires, springs, banks and inner areas of shallow lakes etc.), the *Halohydrophile Type* (salty wetlands), the *Gypsophile Type* (gypsum or chalky soils), the *Haloxerophile Type* (salty soils), along with the *Stony areas Type*, *Karstic limestone sites Type*, *Psammophile Type* (sandy sites) and the *Rocky sites Type* are the main examples of intrazonal vegetation.

Intrazonal types in Canary lands are similar and have de same denominations of those of continental Spain. A *Subhydrophile* variant stands out since its is significant of vegetations where *Phoenix canariensis* occurs.

The vertical structure component

The importance of structural traits has been highlighted by many authors, as Tomaselli (1982), and Küchler (1988). The vegetation structure refers to the density of communities and spatial distribution pattern of dominant species along with the prevailing height in woodstands. The MFE2C takes into account six height categories based on Ruiz de la Torre & Ruiz del Castillo (1977) and Ruiz de la Torre (1990) (Fig. 6):

— Arboreous height. Dominant species exceed 7 m.

— Subarboreous height. Dominant species reach between 3 and 7 m.

— High scrubs. Dominant species reach between 1.5 and 3 m.

— Medium scrubs. Dominant species reach between 0.5 and 1.5 m.

— Low scrubs. Dominant species reach between 0.05 and 0.5 m.

— Dwarf or creeping scrubs. Dominant species do not reach 0.05 m.

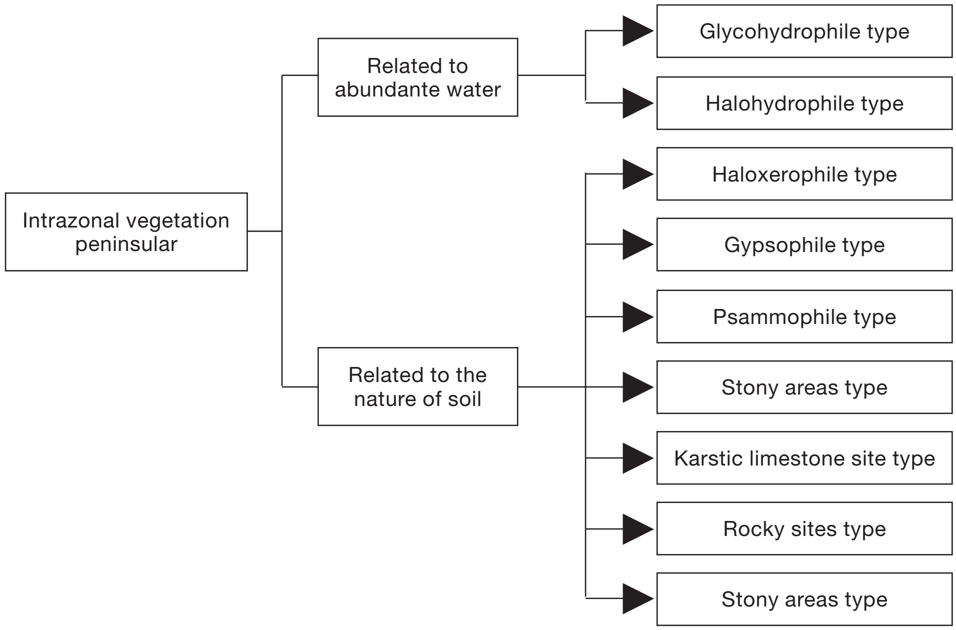

Figure 5. Main climatic-structural intrazonal vegetation types of the Iberian Peninsula and the Balearic Islands.

The phytodynamic component

Dynamic relationships among different units within a certain vegetation domain and also the conception of the potential vegetation or *climax* are complex and often subject of discussion. Both issues are usually based on incomplete or limited synchronous analysis or even on merely empirical considerations.

The MF2C does not deepen into such dynamic relationships in a direct way. But it shows an approach to their assessment based on the concept of *Evolution Level* (EL) (Ruiz de la Torre, 1990a, 1990b). The application of this concept to a specific vegetation patch aims to evaluate its organization and development degree, its diversity and the current use of basic resources (water, energy, nutrients) of the whole plant

Figure 6. Height categories for dominant layer.

cover compared to the optimal state that the environment allows: the most mature community according to site conditions. Thus, the EL is *maturity degree* as well. It has a positive correlation with the hydrological protection role of the plant cover, with stability and with biomass accumulation.

A combination of structural and floristic criteria make possible to assess the EL of a certain patch of vegetation, assigning a number according to its distance from a theoretical desert. The numeric value increase from 0 (desert or complete absence of vegetation) until 9 (highest complexity). CST involving the most severe climatic conditions (*High Mountain* and *Hyperxerophile*) have a lower width of variation, between 0 and 7; intrazonal vegetation can fluctuate between 0 and 6. An indicative outline of the EL according to examples of vegetation units is shown in Figure 7.

The characterization of most mature plant communities has been carried out taking into account more than just theoretical considerations, but also a collection of examples of relict patches. In CST where forests can occur, the highest EL corresponds to multispecific, dense forests with several layers (except for the peninsular *Hyperxerophile*, better simbolized by sparse pine forests of *Pinus halepensis*). In intrazonal types, scenarios are more diverse and complex, i.e. *Glicohidrophile* most developed patches are multispecific forest along riverbanks whilst monospecific grasslands

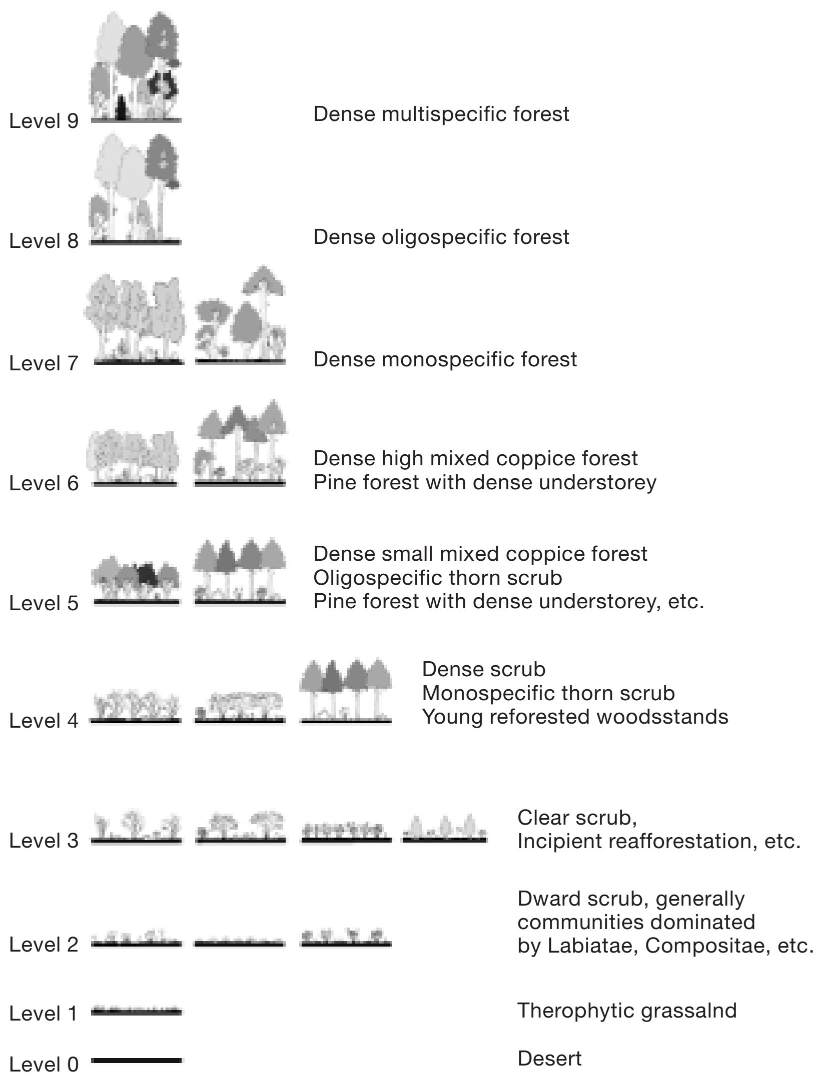

Figure 7. Scale of relationships between evolution levels and examples of plant communities.

with an unique layer represent the highest maturity in many Halohydrophill sites.

Not all vegetation patches within a type domain can reach the maximum EL, as there are natural factors which do not allow that (slope inclination, soil characteristics and depth etc.). This is one of the reasons why many pine forests outside *Taiga-like* and *Hyperxerophile* domains may represent the highest maturity possible despite they do not reach the maximum value (9) in their general area. Similar cases could also be found in highly degraded areas.

The floristic component

This fourth component uses the concept of *plant community* (Ruiz de la Torre, 1977, 1981, 1990) as of a sample of vegetation patch with homogeneous composition and structure. This sense is similar to the meaning given by other authors such as Guinochet (1973) and Küchler (1988) for phytocenose.

Communities are mainly described by their dominant species (Ruiz de la Torre, 1977), either trees, scrubs of different heights or less often herbaceous species. The concept is the most appropriate to refer to non abstract groups and when the study addresses a wide range of technicians and scientists, large areas are studied and there is a limited amount of time to develop the work.

In order to express in the MFE2C the vast existing diversity of plant covers, more than 900 different codes have been adopted for dominant species or mixed communities, often combined among themselves giving therefore a very large number of expressions of floristic composition. The specification of the most abundant communities exceed the aims of this paper; many descriptions, though, can be found in Ruiz de la Torre (1981, 1990). Communities can be qualified as *monospecific*, *oligospecific* and *multispecific*. Monospecific ones are represented by a dominant species (for example, the community of *Cistus ladanifer*). Oligospecific, by 2 or 3 species (i.e., pine forests of *Pinus pinaster* and *Pinus pinea*). Multispecific ones are often expressed by general terms: *fraga* (mixed broadleaf deciduous forests in Galicia, mixed thorn scrub, *mancha* and *garriga* (mediterranean termphile shrublands), mixed heathlands etc.

Material and Methods

Data shown below have been obtained from a group of queries and refinement of the MF2C database. The most general categories have been rejoined in the particular cases of the structure and the plant community due to the long list of units used on the map. The values are expressed in percentages of the total surveyed area or of the area of each *Type*.

The objective of the analysis to be presented is not to carry out a brief description of the Spanish vegetation, but to show its general state from the point of view of each studied characteristic (CST, height, EL, and community).

Results

The surveyed area in the MF2C with non agricultural plant communities in peninsular Spain plus the Balearic Islands is 26,552,231.46 ha (53.3%) and 559,207 ha (72.1%) in the Canary Islands. The number of forest patches studied is 108,427 and 3,458, respectively; so far, the agricultural lands undergoing any type of forest inclusions are not considered in this analysis.

The spatial percentages related to the surveyed area of each CST in peninsular Spain and the Balearic Islands are shown in Figure 8. It can be deduced that the total area supporting forest zonal types is almost 92% of its whole. *Sclerophyll* (34.98%), followed by *Subsclerophyll Type* (32.95%), occupies the largest area; the third *Type* represented is *Deciduous* with 16.97%; *High Mountain, Taiga-like* and *Hyperxerophile* Types mean 1.13, 4.06 and 3.11%, respectively. The Intrazonal vegetations altogether represent 6.80%, which includes those which occur on gypsum (chalky) soil, salty wetlands, river bank forests, estuaries, lakes, rocky areas, *karst*, etc.

In the Canary Islands, percentages occupied by the CST are shown in Figure 9. The zonal forested types represent 28.39%, with 11.69% of *Alize tradewinds forests Type* and 16.70% of *Extra Alize tradewinds forests Type*. The largest type within these islands is *Below potential forest belt Type*, with almost 33%; the intrazonal types, in this case generally non arboreous, cover a conspicuous area (29.9%), mostly located in Lanzarote and Fuerteventura islands.

Dealing with the main vertical structural categories (see Fig. 6), it can be derived that, in zonal peninsular Spain, the arboreous types reach almost 40% of the considered area, while the non arboreous ones make up the remaining 60% (Table 1). An important part is occupied by subarboreous plant covers (21.59%). In non forested lands, prevailing communities are those

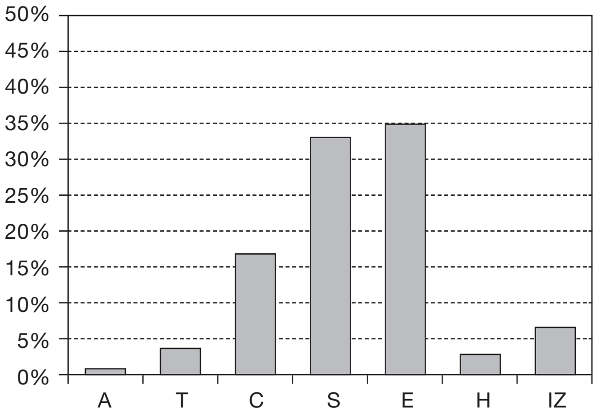

Figure 8. Area percentages of the Climatic-Structural Types for peninsular Spain plus the Balearic Islands regarding the total surveyed area, according to the MF2C. A: High mountain. T: Raiga. C: Deciduous. S: Subsclerophyll. E: Esclerophyll. H: Hyperxerophile. IZ: global set of the Intrazonal vegetation types.

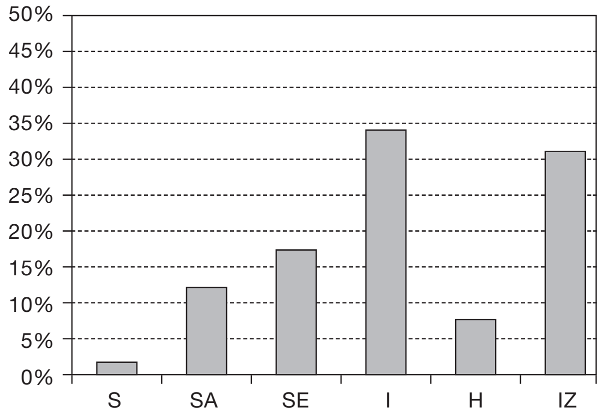

Figure 9. Area percentages regarding the total surveyed area of the main Climatic-Structural Types in the Canary Islands according to the MF2C. S: high mountain type. SA: alize tradewinds forests. SE: extra alize tradewinds forests. I: below potential forest belt. H: hyperxerophile. IZ: group of intrazonal types.

with medium-height (15.67%) and low scrubs (14.17%), whereas high shrublands only represent around 6%. Other categories which do not correspond to the height levels are gathered into a group designated as *Other structures*.

Percentages of areal presence of structure categories and types are shown on Table 2. Values show that CST which have the highest percentages among arboreous category are *Taiga-like* (59.08%) and *Deciduous* (56.37%). At the opposite end, *Hyperxerophile* has the lowest value (just over 9%). *Sclerophyll* (31.50%) and *Subsclerophyll* Types (42.56%) have intermediate values. The intrazonal types, with a significant 28.84%, have an arboreous portion mainly in river forests, and sandy, rocky, karst, or stony soil etc. interspersed in the domains of *Sclerophyll*, *Subsclerophyll*, *Deciduous* and *Taiga-like* Types.

Area percentages occupied by the main vertical structure categories within *Subsclerophyll* and *Sclerophyll* (the most extended types in continental Spain and Balearic Islands) are set out in Figures 10 and 11.

Table 1. Distribution of the main vertical structure categories of peninsular Spain plus Balearic Islands in terms of percentage of the total analyzed area

Height categories	Percentage
Arboreous	39.24
Subarboreous	21.59
High scrubs	5.96
Medium scrubs	15.67
Low scrubs	14.17
Dwarf or creeping scrubs	0.7
Other structures	2.67

In the Canary Islands, the land covered by structure categories according to types is shown in Table 3. It can be stood out from the values that *Alize tradewinds forests* and *Extra Alize tradewinds forests* types represent more than 50% of the area with tree height, reaching 29% in the intrazonal types. Medium scrubs prevail in all types. *Hyperxerophile*, mostly represented by low and medium scrubs, shows a small percentage of subarboreous height which corresponds either to communities of adventitious plants (such as *Nicotiana glauca*) or transitional covers between zonal and intrazonal vegetation (like the small termophile thickets of *Phoenix canariensis*, *Pistacia atlantica* and *Dracaena draco*).

The distribution of areal percentages values obtained from the EL in peninsular Spain and Balearic Islands according to the surveyed total are displayed on Table 4, along with the Canary Islands values on Table 5.

Approximately 38% of the area within *High Mountain Type* domain has medium and high levels (between 4 and 7). The data analysis reveal that 23.1% has very low levels (from 0 to 2), although they partially include the most possible high complex plant covers due to the particular site conditions in this altitudinal belt.

In *Taiga-like* almost 60% is valued with levels between 5 and 7, considerable maturity degrees related to good protection conditions in headwater areas of catchments where they are located. A significant 40% is constituted by plant communities which can increase their maturity.

Table 2. Contingency table of areas according to climatic-structural types and vertical structure categories in peninsular Spain and the Balearic Islands

Heights	Climatic-structural types						
	High mountain	Taiga	Deciduous	Subsclerophyll	Sclerophyll	Hyperxerophile	Intrazonal
I	0.00	59.08	56.37	42.56	31.50	9.31	28.84
II	0.10	3.83	2.11	25.82	32.71	17.89	8.69
III	0.51	2.62	4.03	5.31	8.50	5.50	4.06
IV	25.00	12.95	18.84	13.64	14.77	40.76	11.04
V	55.00	12.68	18.20	11.97	11.21	18.05	22.40
VI	17.29	8.71	0.34	0.13	0.03	0.05	0.53
VII	2.10	0.13	0.11	0.57	1.28	8.44	24.44
Total	100	100	100	100	100	100	100

I: arboreous heights. II: subarboreous. III: high scrubs. IV: medium scrubs. V: low scrubs. VI: very low or creeping scrubs. VII: other structures.

Deciduous presents prevalence of low EL, just above 51% with values between 0 and 3. A 27% has values between 5 and 9, and there is also a small but significant percentage (1.37%) of vegetation with levels 8 and 9.

In the case of *Subsclerophyll* (Fig. 12), almost 40% has levels between 5 and 8 whereas low mature plant covers (levels 0 to 3) appear with a little more than 30%.

Outstandingly mature vegetation (levels 5 to 9) represents just over 25% in *Sclerophyll* domain (Fig. 13). The most degraded or incipient areas (degrees 0 to 3) occupy almost 40%. A significant 0,87% has levels between 0 and 1, revealing severe problems of protection against water erosion and therefore of desertification due to plant cover lack.

In the peninsular *Hyperxerophile* only 25.2% means high *levels* (4 to 7). At the opposite end, around 30% represents the most degraded or incipient vegetation (between 0 and 2), which has a low protection capacity against water erosion and is extremely vulnerable to desertification.

In the Canary Islands, the highest areal percentages of most mature plant covers can be found in *Alize tradewinds forests* (57.9% between values 5 and 9) and *Extra Alize tradewinds forests* types (53.1% between 5 and 9). Largest areas of low levels are located in *Below potential forest belt* (37% between values 0 and 2) and in *Hyperxerophile* (more than 60% between 0 and 1).

Plant communities occuring within each CST would form very long lists. In order to simplify the exposition

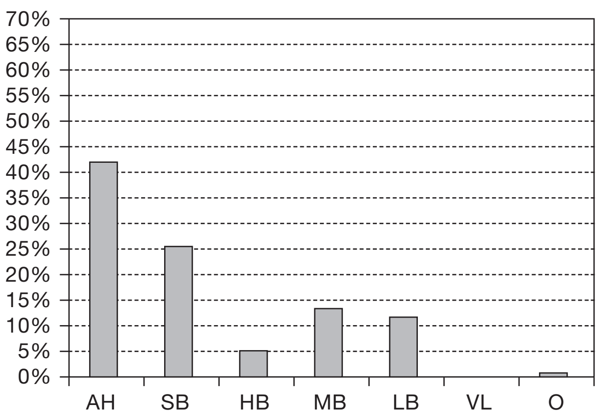

Figure 10. Areal distribution of the main vertical structure categories within Subsclerophyll in continental Spain. AH: arboreous height. SH: subarboreous. HS: high scrub. MS: medium scrub. LB: low scrub. VL: very low or creeping scrub. O: other structure categories.

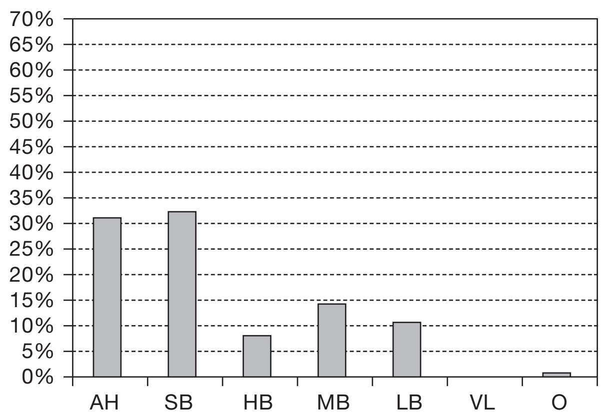

Figure 11. Areal distribution of the main vertical structure categories within Sclerophyll Type in continental Spain and the Balearic Islands. AH: arboreous height. SH: subarboreous. HB: high scrub. MB: medium scrub. LB: low scrub. VL: very low or creeping scrub. O: other structure categories.

Table 3. Contingency table of areas according to Climatic-Structural Types and vertical structure categories in Canary Islands

Heights	Climatic-structural types					
	High mountain	*Alize tradewinds* forests	Extra *Alize tradewinds* forests	Below forests range	Hyperxerophile	Intrazonal
I	—	53.62	62.37	—	—	29.04
II	—	19.48	4.36	1.43	1.51	0.15
III	47.83	7.75	6.62	9.87	0	2.84
IV	51.78	10.1	17.92	55.79	35.48	11.76
V	0.39	4.93	4.57	18.34	53.71	2.46
VI	0	0	0	2.11	0	0
VII	0	4.12	4.16	12.46	9.3	53.75
Total	100	100	100	100	100	100

I: arboreous heights. II: subarboreous. III: high scrubs. IV: medium scrubs. V: low scrubs. VI: very low or creeping scrubs. VII: other structures.

Table 4. Area percentages and evolution levels per climatic-structural type of peninsular Spain and the Balearic Islands

Levels	Climatic-structural types					
	High mountain	Taiga	Deciduous	Subsclerophyll	Sclerophyll	Hyperxerophile
9	—	0.00	0.10	0.00	0.00	—
8	—	0.00	1.27	0.01	0.00	—
7	0.42	15.66	8.33	2.73	0.86	0.00
6	0.50	19.61	8.52	9.95	5.11	1.17
5	9.84	24.57	8.97	26.88	19.56	7.79
4	27.67	18.05	21.35	27.67	36.10	16.23
3	38.48	17.89	40.98	26.00	28.07	45.16
2	18.42	3.24	10.35	6.41	9.43	27.05
1	4.50	0.93	0.05	0.28	0.36	1.75
0	0.17	0.06	0.09	0.07	0.51	0.85
Total	100	100	100	100	100	100

Table 5. Area percentages and Evolution Levels for the Climatic-Structural Type for the Canary Islands

Levels	Climatic-structural type				
	High mountain	*Alize tradewinds* forests	Extra *Alize tradewinds* forests	Below potential forest belt	Hyperxerophile
9	—	0.00	—	—	—
8	—	6.21	—	0.00	—
7	—	7.52	—	0.00	—
6	18.26	23.84	24.98	0.20	—
5	13.87	20.39	28.13	6.29	0.00
4	64.25	26.13	31.84	36.92	1.41
3	3.62	12.03	9.44	18.96	2.26
2	0.00	3.88	1.97	15.38	34.72
1	0.00	0.00	0.00	12.87	60.23
0	0.00	0.00	3.64	9.38	1.38
Total	100	100	100	100	100

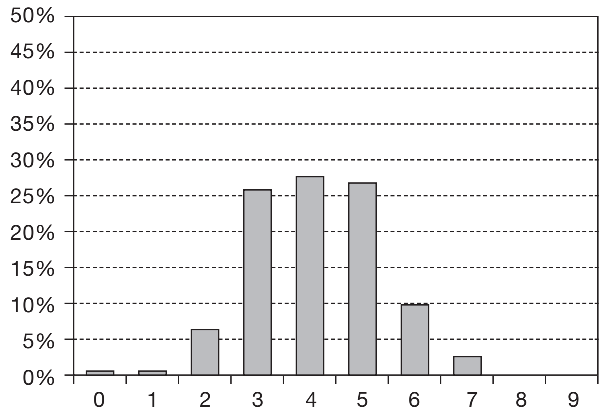

Figure 12. Areal distribution of evolution levels in subsclerophyll type.

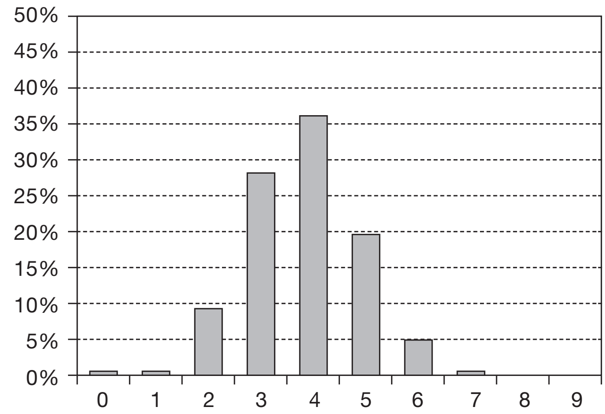

Figure 13. Areal distribution of evolution levels in sclerophyll type.

they have been joined together according to their similar physiognomy. The results of the percentages of plant cover occupation in the different CST are set out in the following tables.

The main sets of *High Mountain Type* plant communities are shown on Table 6. Dense high-mountain grasslands represent the largest area and are especially abundant in the Pyrenees and the Cantabrian Range; such herbaceous covers are dominated by a wide variety of species of the genera *Carex*, *Nardus*, *Festuca*, *Trifolium* etc. Rocky and stony deserts (plant cover less than 5%) and semi-deserts (between 5 and 10%) reach the second position; their origin is mostly natural and they are very common in high mountain belts. The third group is made up of diverse broom-like scrubs (18.14%), with major prevalence of *Cytisus purgans* (= *Cytisus oromediterraneus*). Depending on the case, heathlands (17.95%) are mostly dominated by *Erica arborea*, *Erica vagans* or *Calluna vulgaris*. Other grasslands include high *lastonares* (typical in southern mountain ranges in Spain, represented by genera *Festuca*, *Agrostis*, *Trisetum, Helictotrichon* etc.) and *estepas leñosas* (mixtures of grasses and dwarf scrubs of genera *Festuca*, *Helictotrichon*, *Agrostis*, *Arenaria*, *Thymus* etc. The rest of groups in the phytocenose has percentages lower than 5%.

Within the *Taiga-likeType* (Table 7), largest occuring communities are *Pinus sylvestris* forests (46.59%); other

Table 6. Main plant communities in the High mountain type and its area percentages

High mountain type	
Plant community	**% of area**
Dense, high mountain grassland	28.18
Rocky and stony deserts and semi-deserts	20.43
Broom-like scrubs	18.14
Mono- oligo- and multispecific heathlands	17.95
Other communities with prevalence of *Gramineae*	6.49
Mono- and oligospecific thorny scrubs	3.79
Communities of *Juniperus communis*	2.21
Oligo- and multispecific non thorny scrubs	1.51
Communities of *Juniperus sabin*a and *Juniperus communis*	0.53
Others	0.77

Table 7. Main plant communites in the Taiga-like type and area percentages

Taiga-like type	
Plant community	**% of area**
Pine forests (most dominant *Pinus sylvestris*)	46.59
Dense high-mountain grassland	10.21
Pine forests (most dominant *Pinus uncinata*)	10.09
Broom-like scrubs (genera *Cytisus* and *Genista*)	8.00
Mono- , oligo- , multispecific scrubs	4.86
Monospecific and oligospecific thorny scrubs	2.81
Oligospecific and multispecific heathlands	2.49
Fir forests (most dominant *Abies alba*)	2.09
Pine forests (most dominant *Pinus nigra*)	2.06
Pastures	1.56
Communities of *Juniperus communis*	1.18
Communities of *Juniperus sabina* and *Juniperus communis*	1.07
Communities of *Juniperus sabina*	0.92
Mixed grassy-woody pastures	0.91
Birch forests (most dominant *Betula* spp.)	0.47
Communities of *Juniperus thurifera* as most dominant	0.24
Fir forests (most dominant *Abies pinsapo*)	0.20
Others	4.25

pine forests occupy smaller areas: *Pinus uncinata* (10.09%) and *Pinus nigra* (2.06%). Forests with first dominant species being *Abies alba* represent just over 2%. The different communities dominated by *Cupressaceae* reach 3.37% (0.2% of *Juniperus thurifera*). *Abies pinsapo* (0.20%) and *Betula* (0.47%) communities have a smaller importance. Dense, high mountain grasslands of genera *Festuca*, *Carex* and *Agrostis* make up a significant set (10.21%), spread mainly throughout the Cantabrian and the Pyrenees ranges. Broom-like scrubs (8%), with species such as *Cytisus purgans*, *Genista obtusiramea* and a lesser extent of *Genista florida* and *Genista* gr. *cinerea*, represent a conspicuous group as well. Non thorny scrubs (4.86%) bring together a wide variety of communities dominated by genera such as *Vaccinium*, *Arctostaphylos*, *Rhododendron*, *Buxus*, *Coronilla*, *Helianthemum*, *Thymus* etc. There is a smaller abundance of thorny scrubs (2.81%) which contain species of the genera *Genista*, *Echinospartum*, *Erinacea*, along with non spiny plants such as *Thymus* etc. Dominant taxa are *Erica* and *Calluna vulgaris* in heathlands (2.49%).

In the *Deciduous Type* vegetation (Table 8), the monospecific beech forests (*Fagus sylvatica*) mean the largest area (10.99%) along with multi- and oligospecific forests (8.59%) made up of several proportions of species belonging to the genera *Quercus* (*Q. robur*, *Q. pyrenaica* and *Q. petraea* in a lesser extent), *Betula*, *Castanea*, *Prunus*, *Sorbus*, *Acer*, *Tilia* and even *Fraxinus*. Monospecific oak forests of *Quercus robur* (2.86%), *Quercus pyrenaica* (2.49%) and *Quercus petraea* (1.01%) are less abundant. In connection with conifers presence, pine forests of *Pinus pinaster* (9.52%) play an important role, followed by *Pinus radiata* (6.67%) and finally *Pinus sylvestris* (3.80%). *Eucalyptus* forests (almost solely of *Eucalyptus globulus*), represent 6.96%. The most abundant non arboreous communities are scrubs of *Ulex* species (12.56%), pastures (12.00%) and several heathlands (5.87%), mainly with *Erica vagans*.

Communities of *Quercus* are the most abundant plant covers in the *Subsclerophyll Type* vegetation (Table 9), then followed by shrublands (just over 27%) and pine forests (almost 25%); *Quercus ilex* forests represent the first main position (15.25%), usually with other co-dominant taxa such as *Quercus faginea*, *Quercus pyrenaica* (both of them being characteristic of this Type) and *Pinus* species. Oligo- and multispeci-

Table 8. Main plant communities in the Deciduous type and area porcentages

Deciduous type	
Plant community	**% of area**
Mono- and oligospecific communities of *Ulex* spp.	12.56
Pastures	12.00
Beech forests (most dominant *Fagus sylvatica*)	10.99
Pine forests (most dominant *Pinus pinaster*)	9.52
Deciduous multi- and oligospecific forests	8.59
Blue gum forests (most dominant *Eucalyptus globulus*)	6.96
Pine forests (most dominant *Pinus radiata*)	6.67
Oligo- and multispecific heathlands	5.87
Mixed grassy-woody pastures	4.08
Pine forests (most dominant *Pinus sylvestris*)	3.80
Oak forests (most dominant *Quercus robur*)	2.86
Broom-like scrubs	2.81
Oak forests (most dominant *Quercus pyrenaica*)	2.49
Sweet chestnut forests (most dominant *Castanea sativa*)	1.43
Oak forests (most dominant *Quercus petraea*)	1.01
Fern communities (*Pteridium aquilinum*)	0.97
Others	7.39

Table 9. Main plant communities in the Subsclerophyll type

Subsclerophyll type	
Plant community	**% of area**
Oak forests (most dominant, *Quercus ilex*)	15.25
Oligo and multispecific non thorny scrubs	10.64
Oak forests (most dominant, *Quercus pyrenaica*)	10.16
Pine forests (most dominant, *Pinus nigra*)	8.61
Oak forests (most dominant, *Quercus faginea*)	7.01
Pine forests (most dominant, *Pinus sylvestris*)	6.56
Pine forests (most dominant, *Pinus pinaster*)	6.26
Grasslands	5.24
Oligo- and multispecific heathlands	3.46
Mono and oligospecific thorny bushswood	3.23
Pine forests (most dominant *Pinus halepensis*)	2.76
Communities most dominant *Juniperus thurifera*	2.49
Broom-like scrubs	2.36
Cork oak forests (most dominant, *Quercus suber*)	2.23
Mono and oligospecific communities of *Cistus* spp.	1.61
Communities of *Buxus sempervirens*	1.00
Sweet chestnut forests (most dominant *Castanea sativa*)	0.84
Oak forests (most dominant *Quercus humilis*)	0.76
Pine forests (most dominant *Pinus pinea*)	0.63
Blue gum (mainly *Eucalyptus globulus*)	0.35
Pine forests (most dominant *Pinus radiata*)	0.14
Others	8.41

fic non thorny scrubs are the second most significant phytocenoses (10.64%), an extremely diverse group of Mediterranean scrubs with many co-dominant species of genera *Halimium*, *Thymus*, *Genista*, *Lavandula*, *Cistus*, *Adenocarpus*, *Ononis*, *Erica*, *Satureja*, *Helianthemum*, *Helichrysum* etc. The third posititon corresponds to *Quercus pyrenaica* communities (10.16%), either monospecific or mixed with other species such as *Quercus ilex*, *Quercus faginea*, *Pinus sylvestris* etc. *Quercus faginea* oak forests represent 7.01% and are usually accompanied by *Quercus ilex* or *Pinus nigra*; these last two species are nowadays in clear progression due to the abandonment of grazing activities and the sheltering provided by pine or *Quercus ilex* forests which leads to believe that in the near future there will be a considerable increase in their prevalence. *P. nigra* forests are the most abundant pine communties (8.61%), followed by *P. sylvestris* (6.56%) and *P. pinaster* (6.26%). Grasslands (5.24%) represent a vast set of plant covers dominated by herbaceous taxa. Other groups are represented by less than 5%.

The relative abundance of plant covers belonging to the *Sclerophyll Type* vegetation is set out in Table 10.

Table 10. Main Sclerophyll type plant community

Sclerophyllous type	
Plant community	**% of area**
Oak forests (most dominant, *Quercus ilex*)	36.22
Pine forests (most dominant, *Pinus halepensis*)	13.90
Oligo and multispecific non thorny scrubs	8.53
Grasslands	7.20
Cork oak forests (most dominant, *Quercus suber*)	4.66
Pine forests (most dominant *Pinus pinaster*)	3.84
Broom-like scrubs	2.98
Pine forests (most dominant, *Pinus pinea*)	2.92
Blue gum forests (mainly *Eucalyptus globulus*)	2.87
Mono- and oligospecific thorny scrubs	2.16
Mono- and oligospecific communities of *Rosmarinus officinalis*	2.07
Communities of *Cistus ladanifer*	1.90
Communities *Quercus coccifera* as dominant	1.59
Communities of *Stipa tenacissima*	0.88
Oligospecific communities of *Cistus* spp.	0.65
Pine forests (most dominant *Pinus nigra*)	0.55
Communities *Olea europaea* as most dominant	0.44
Communities of *Juniperus oxycedrus*	0.43
Oligo- and multispecific heathlands	0.14
Communities of *Juniperus thurifera* as most dominant	0.08
Pine forests (most dominant, *Pinus sylvestris*)	0.07
Others	5.92

Species of the genera *Quercus* (with just over 42%) and *Pinus* (just over 21%) are the most dominant. The set which covers the largest area is the holm oak forests (most dominant *Quercus ilex* subsp. *ballota* and to a lesser extent subsp. *ilex*), which includes most of *dehesas* and a large amount of shrublands; these communities are frequently co-dominated by *Quercus suber*, *Pinus pinaster*, *Pinus halepensis* and *Juniperus thurifera*. The second most abundant community are the pine forests, generally dominated by *Pinus halepensis* with an important role as they protect soil against erosion and desertification. The third position corresponds to a heterogeneous group of scrubs (8.53%) made up of a wide variety of mostly non thorny, non broom-like species of genera *Cistus*, *Halimium*, *Thymus*, *Lavandula*, *Pistacia*, *Phillyrea*, *Rhamnus*, *Genista*, *Ononis*, *Thymelaea* etc. Grasslands are less significant (7.20%). Scrubs of *Rosmarinus officinalis* make up over 2%. There is a smaller presence of different communities of *Cistus* (mainly, *Cistus ladanifer*), along with communities of *Stipa tenacissima* and several types of heathlands.

Retama sphaerocarpa prevails in most of the broom-like scrubs (2.98%). For mono- and oligospecific thorny scrubs, the most important species are *Genista scorpius*, *Ulex parviflorus*, *Ulex eriocladus* and other related taxa. It is worth pointing out that in this *Type* there is a marginal presence of pine tree forests of *Pinus nigra* and *Pinus sylvestris*, as well as communities of *Juniperus thurifera*.

The main *Hyperxerophile Type* plant communities and their relative area are shown on Table 11. *Pinus*

Table 11. Main hyperxerophile type plant community

Hyperxerophile type	
Plant community	**% of area**
Pine forests of *Pinus halepensis* as most dominant	30.83
Communities of *Stipa tenacissima*	26.61
Oligo- and multispecific scrubs	17.19
Communities of *Anthyllis cytisoides*	6.96
Mono- and oligospecific communities of *Rosmarinus officinalis*	4.02
Mono- and oligospecific communities of *Artemisia herba-alba*	3.54
Communities of *Chamaerops humilis*	1.18
Communities of *Retama sphaerocarpa*	0.93
Grasslands	0.58
Communities of *Juniperus thurifera* as most dominant	0.05
Others	8.11

halepensis forests and the *Stipa tenacissima* grassland are the most important. The third most abundant is a heterogeneous set of oligo- and multispecific scrubs; when occuring in the southeastern Iberian peninsula the most dominant species are *Pistacia lentiscus*, *Periploca laevigata*, *Launaea arborecens*, *Anthyllis cytisoides*, *Anthyllis terniflora*, *Helianthemum* spp., *Thymus hyemalis*, *Hyparrhenia hirta*, *Brachypodium retusum* and obviously *Stipa tenacissima* and *Rosmarinus officinalis* are also present. In the Ebro valley there are *Genista scorpius*, *Helianthemum* spp., *Globularia alypum*, *Teucrium capitatum*, *Sideritis* spp., *Cistus clusii*, *Brachypodium retusum*, *Stipa* spp., along with *Rosmarinus officinalis*. The fourth most abundant communities are those dominated by *Anthyllis cytisoides* (6.96%), which are very common in southeastern Spain, most coming from the abandonment of former agricultural crops. The rest of communities occupy smaller area.

For the Canary Islands, the most abundant broom-like scrubs are *Spartocytisus supranubius* communities, in the *High Mountain Type*, which reach 80.51% of the total area, due to the existence of large lavae zones included in intrazonal types. At a lower altitude, in the area of the *Alize tradewinds forests Type*, the most significant communities are *fayal-brezales* (27.32%), *Pinus canariensis* forests (14.14%) and *laurisilvae* (8.82%). In the *Extra Alize tradewinds forests Type*, the importance is shared by the Canary pine forests (60.78%), communities dominated by *Cistus symphytifolius* and/or *Cistus monspeliensis* (8.41%) and the broom-like scrubs of *Chamaecytisus proliferus* (5.70%). The Below potential forest belt *Type* is the richest in plant communities with abundant multi- and oligospecific scrubs (44.12%), communities of *Launaea arborescens* (14.25%), *tabaibares* of *Euphorbia balsamifera* (7.88%) and *cardonales Euphorbia canariensis* (3.18%). The *Hyperxerophile Type*, where semideserts are dominant (51.91%) as well as scrubs with *Salsola vermiculata* (33.78%), is much poorer in terms of plant covers.

Conclusions

The original descriptive elements used in the creation of the Forest Map 1:200,000 (climatic-structural domains, vegetation vertical structure, EL and plant communites) may make the interpretation somehow complex but they provide a valuable cartographic tool which is extremely close to the real complexity of the elements that have been described.

Until now the main updated information available on the plant cover of Spain came from the National Forest Inventory (*Inventario Forestal Nacional*) which analyzes a small group of species and plant mixtures and assesses a set of parameters (tree cover areas, altitude, growths etc.) that were all expressed in terms of spatial administrative units (autonomous regions, provinces, national parks etc.). The MF2C, as derived from the shown results, provides a highly valuable group of complementary data: a deep description of plant communities, further details on structure distribution (especially non arboreous structures) and an evaluation of the general maturity level (that will allow the analysis of trends by comparing different periods). All such information is spatially related to the large phytoclymatic areas.

MFE2C data show that the largest part of continental Spain's forest area is included in the domain of potential forests, with 92% corresponding to zonal Types. This value contrasts to the current situation in which only 40% reaches arboreous height (above 7 m), although there is a substantial 21.6% of subarboreous height (between 3 and 7 m). It is remarkable that an important part of the area is covered by scrubs, which make up around 40% of peninsular Spain. In the Canary Islands, however, as much as 70% of the area lays on the potential domain of non arboreous plant covers (natural absence of forests).

The largest percentages of the forested area in peninsular Spain (between 50 and 60%) belong to *Taiga-like* and *Deciduous* Types, whilst the *Hyperxerophile* area is at the other end of the scale, with the smallest percentage (less than 10%) of tree communities. Moreover, the high percentages (between 25 and 30%) of *Subsclerophyll* and *Sclerophyll* scrubs heights are also noteworthy, many of them being coppiced forest of tree species from seedlings. In the Canary Islands, the *forest* types cover more than 50 of the potential forest domain.

The application of the concept *Evolution Level* shows a very different sketch depending on which *Climatic-Structural* domain is considered. It is noteworthy that the highest *evolution levels* are found in *Deciduous Type*; however, *Subsclerophyll* and *Taiga-like* Types have the largest area of medium and high evolution degrees. The peninsular *Hyperxerophile* appears at the opposite end, with the smallest values. The Canary Islands show a similar trend: prevalence of high and medium values in the *High Mountain Type* compared to low and medium values in the Below potential forest belt. In the *Alize tradewinds Type* there are only high *levels* (between 7 and 9) 13.7%.

Regarding the plant communities and despite the synthesis hereby used, there is a outstanding heterogeneity in all Types, although only several tree species (genera *Pinus*, *Quercus* and *Fagus*) are greatly important. There is also an extraordinary diversity of non arboreous communities, especially in mixtures (heathlands, thorny or non thorny oligo- and multispecific scrubs) and in those of broom-like physiognomy. In the Canary Islands there is a current low presence of laurisilva forests (less than 10% in the natural region) as well as of *cardonal* (*Euphorbia canariensis*).

Aknowledges

The authors want to thank Prof. Dr. Alberto Pardos Carrión, Prof. Dr. Alberto Madrigal Collazo, Dr. Ramón Villaescusa Sanz and For. Eng. Roberto Vallejo Bombín their useful contributions, suggestions and data.

References

ALLUÉ CAMACHO M., 1996. Vegetación. In: Mapa Forestal de España, Hoja 5-5, Segovia, ICONA, Madrid. pp. 7-147.

CASALS COSTA V., 1996. Los ingenieros de montes en la España contemporánea 1848-1936. Ediciones Serbal, Barcelona. 432 pp.

DÍAZ GONZÁLEZ T.E., FERNÁNDEZ PRIETO J.A., 1998. Vegetación. In: Mapa Forestal de España, Hoja 4-2, Mieres, Dirección General de Conservación de la Naturaleza. pp. 111-147.

GUINOCHET M., 1973. Phytosociologie. Masson et Cie, Paris. 227 pp.

KÜCHLER A.W., 1988. A Physionomic and structural análisis of vegetation. In: Vegetation mapping, Kluwer Academic Publishers, Dordrecht, Netherlands. 635 pp.

LÓPEZ LEIVA C., 1995. Vegetación. In: Mapa Forestal de España, Hoja 8-6, Vinaroz, Dirección General de Conservación de la Naturaleza. pp. 61-108.

MONTSERRAT P., 1990. Vegetación. In: Mapa Forestal, Hoja 8-2, Viella, ICONA. pp. 43-67

MONTSERRAT P., 1992. Vegetación. In: Mapa Forestal, Hoja 8-3, Huesca, ICONA. pp. 53-82.

QUEZEL P., 1982. Los bosques en la cuenca mediterránea. In: Bosque y maquia mediterráneos, ecología, conservación y gestión. Serbal-UNESCO, Barcelona, España. pp. 9-57.

RUIZ DE LA TORRE J., RUIZ DEL CASTILLO J., 1977. Metodología y codificación para le análisis de la vegetación española. Trabajos de la cátedra de Botánica, Sección de Publicaciones, ETSI Montes, Madrid. 47 pp.

RUIZ DE LA TORRE J., 1977. Especies dominantes en la vegetación española peninsular. Boletín de la Estación Central de Ecología., Año VI, Número 11. pp. 13-24

RUIZ DE LA TORRE J., 1981. Vegetación. In: Tratado del Medio Natural. Universidad Politécnica de Madrid-CEOTMA, Madrid. pp. 1-79.

RUIZ DE LA TORRE J., 1990. Mapa Forestal de España, 1:200.000, Memoria General, ICONA, Madrid. 191 pp.

RUIZ DE LA TORRE J., 1990. Distribución y características de las masas forestales españolas. Ecología Fuera de Serie 1, 11-30.

TOMASELLI R., 1982. Degradación de la maquia mediterránea. En: Bosque y maquia mediterráneos, Serbal-UNESCO, Barcelona, España. pp. 59-134.

VEIJOLA, P., 1998. The northern timberline and timberline forests in Fennoscandia. The Finnish Forest Research Institute, Research Papers 672, Kolari. 242 pp.

VILLAR L., 1990. Vegetación. En: Mapa Forestal, Hoja 7-4, Zaragoza, ICONA. pp. 51-78.