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The woody vegetation in the Mediterranean-atlantic boundary in the north-west of the Iberian Peninsula

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ABSTRACT

MORLA, C. & F. D. PINEDA (1985). The woody vegetation in the Mediterranean-atlantic boundary in the north-west of the Iberian Peninsula. *Candollea* 40: 435-446. In English, Spanish abstract.

The boundary between Mediterranean and Euro-Siberian environments in the north-west of the Iberian Peninsula is both intereting and rare, due to the complex confluence of floristic components and abiotic environmental factors of differing types which has attracted the attention of botanists and geographers. The present article describes the structure of the woody vegetation of part of this area, quantifying the influence of certain geomorphological parameters on the composition and distribution of different communities. Information was gathered for biotic and physical data, the latter for their probable value as indicators and for their ready availability. The data were collected using stratified sampling and were analysed through multivariate analysis. The phytosociological characteristics of the vegetation cover studied were interpreted in terms of environmental variation. For each community identified, the most representative species and their variability were related to the variation in parameters of local climate which explained vegetation distribution satisfactorily.

RESUMEN

MORLA, C. & F. D. PINEDA (1985). La vegetación leñosa del límite Mediterraneo-atlantico de la zona noroeste de la Península Ibérica. *Candollea* 40: 435-446. En español, resumen inglés.

En las montañas gallegas y leonesas del N.W. de España, tiene lugar una transición entre ecosistemas de tipo mediterráneo y eurosiberiano. La frontera entre estos dos ambientes presenta un interés y originalidad notables, sobre todo por la confluencia compleja de componentes florísticos y factores ambientales abióticos de diferente entidad, lo que ha llamado la atención de botánicos y geógrafos. En este artículo se describe la estructura vegetal leñosa de una porción de este territorio, cuantificando la influencia de determinados parámetros geomorfológicos en la composición y distribución de las distintas comunidades. El registro de la información se ha practicado mediante la prospección simultánea de datos bióticos y físicos. Los primeros son de carácter cualitativo (presencia-ausencia de las especies leñosas en parcelas de muestreo) y los segundos, estimados cuantitativamente, se han seleccionado por su presumible valor indicador y la accesibilidad de su medida. La información se obtuvo mediante muestreo estratificado, practicándose dentro de cada estrato otro muestreo regular. Los datos se procesaron mediante análisis multivariante. Las características fitosociológicas de la cubierta vegetal estudiada se interpretan en términos de variación ambiental. Para las comunidades detectadas, se señalan las especies más representativas de acuerdo con su carácter discriminante, estableciéndose para aquéllas la variación de los dos parámetros físicos de carácter mesoclimático, que resultaron explicar satisfactoriamente la distribución de la vegetación.

Introduction

The study of boundaries separating different types of ecosystems has attracted much interest both at a general geographical and at a detailed scale (see, for example, SHELFORD, 1963; MARGALEF, 1974; SOLNTSIEV, 1977). At the general scale attention has focussed on the role played by geological and climatological factors in the spatial segregation of species and com-

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munities (CURTIS, 1959; LATTIN, 1967). At the more detailed scale studies have centered on questions of floristic affinity between species (GODRON, 1968; RIVAS-MARTÍNEZ, 1973), environmental gradients (GARCÍA-NOVO & al., 1969; WHITTAKER, 1970; AUSTIN & NOY-MEIR, 1971; RAMÍREZ & al., 1976), asymmetry (VAN DER MAAREL & WESTHOFF, 1964; VAN DER MAAREL, 1966; MARGALEF, 1974) and, more recently, on relations of competition and spatial segregation associated to ecological succession (AUSTIN, 1977; PINEDA & al., 1981a, b).

At local geographical scales the limit between the different phytogeographical units also presents great interest, through studies of the composition and spatial distribution of vegetation communities in critical, transition areas rich in marginal situations particularly if, as in this case, the presence of the anthropological environmental factors so important in the Mediterranean Basin are considered.

In the north-west of the Iberian Peninsula two very different units come into contact: the Mediterranean region and that of an Atlantic dominated Euro-Siberian region (BRAUN-BLANQUET, 1923; WALTER, 1927, 1954). Various authors have pointed out the difficulties involved in identifying definite limits between these areas to the west of the Cordillera Cantábrica (DUPONT, 1962; RIVAS-MARTÍNEZ & RIVAS-GODAY, 1976; RIVAS-MARTÍNEZ, 1981a, b; IZCO, 1982), where this mountain barrier no longer acts to differentiate these regions. The mountains of Galicia and León, to the west of the Cordillera Cantábrica, are lower in altitude and branch in a tree-like manner to the west, the boundary that they represent thereby favouring complex contacts between different types of ecosystems. The valleys of the River Sil and it's tributaries represent Mediterranean type enclaves in the west and the mountains in which they are found represent zones of transition from the Atlantic influence (DUPONT, 1959, 1962).

Figure 1 indicates the geographical location of the study area in question, an area of approximately 50.000 hectares in the mountainous system of Queixa and San Mamed in the Orense Province. Changes in relief are abrupt and allow the differentiation, along a S-N axis, of the following units:

— *Upper zone:* with peaks between 1200 and 1778 m asl, corresponding to erosion zones with steep slopes. The head valley of the drainage network are open and may show features of previous glacial activity. The vegetation is dominated by shrubs and high altitude pastures of *Festuca ovina* L. subsp. *indigesta* (Bss) Hack, and *Nardus stricta* L. The major landuse has been livestock raising with goats and sheep, which periodically employed fire, a very characteristic anthropological action. In recent decades afforestation has been undertaken with *Pinus sylvestris* L.

— *Intermediate mountainous zone:* 400 to 1200 m in height, with wide areas of erosion, shallow slopes and rivers flowing in increasingly enclosed valleys. This topography, in conjunction with microclimatic conditions, has favoured intense human agrarian activity (rye, potatos, allotments and hay crops). The human population tends to concentrate in this zone in hamlets, resulting in a mosaic of characteristic agrarian elements (MORLA-JUARISTI, 1984).

— *Lower zone:* a zone, under 400 m in altitude, of spacious water sheds between which rivers flow in very narrow valleys, resulting in abrupt relief. This has not hindered the development of important agricultural activity as warm climatic conditions and important land preparation works (terracing and access tracks along slopes) have permitted the cultivation of vines, olives and early fruits.

Methodology

The study of the transition between the two biogeographical regions considered using transects perpendicular to their border is very difficult. Such a method has proved successful in detailed ecological studies (for example, PINEDA & al., 1981b; DE PABLO & al., 1982; CASADO & al., 1984), but the presence of mountain chains in the area considered here favours the existence of small environmental islands or units on either side of an already unclear boundary, so complicating

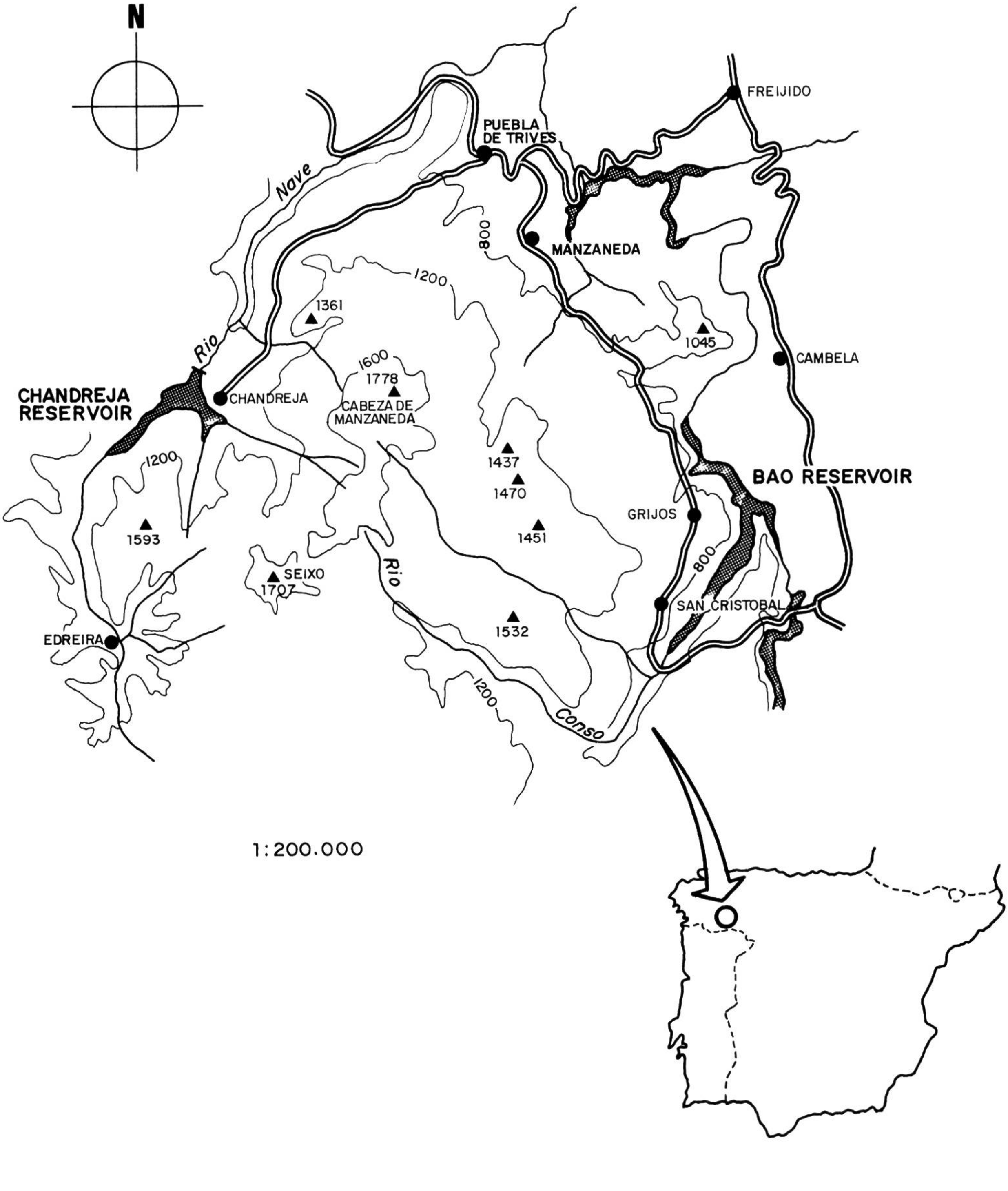
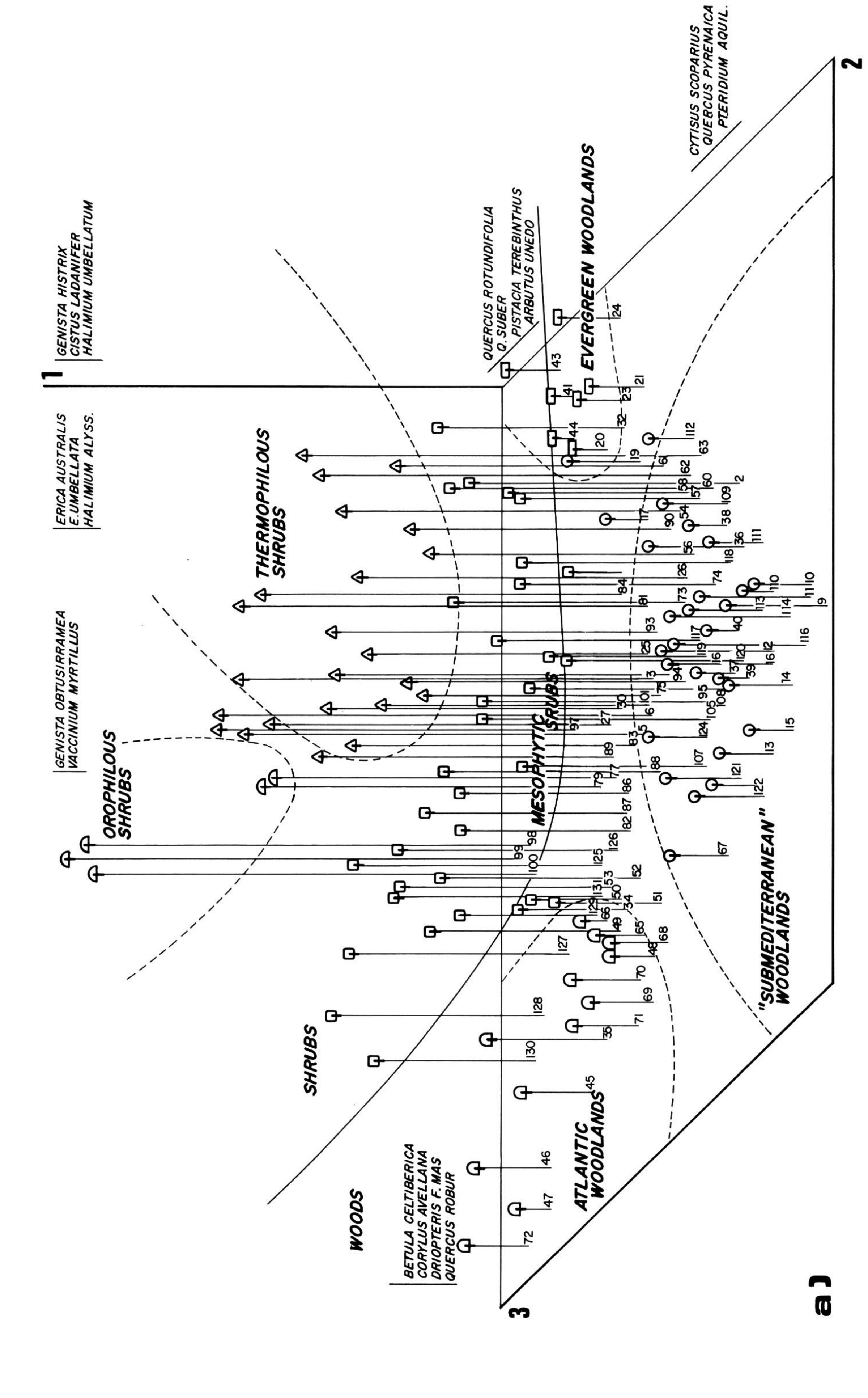


Fig. 1. — Geographical location of the study area.


GENISTA HISTRIX
CISTUS LADANIFER
HALIMIUM UMBELLATUM
ERICA AUSTRALIS
E. UMBELLATA
HALIMIUM ALYSS.
GENISTA OBTUSIRRAMEA
VACCINIUM MYRTILLUS
OROPHILOUS SHRUBS
THERMOPHILOUS SHRUBS
MESOPHYTIC SRUBS
SHRUBS
WOODS
BETULA CELTIBERICA
CORYLUS AVELLANA
DRIOPTERIS F. MAS
QUERCUS ROBUR
ATLANTIC WOODLANDS
"SUBMEDITERRANEAN" WOODLANDS
EVERGREEN WOODLANDS
QUERCUS ROTUNDIFOLIA
Q. SUBER
PISTACIA TEREBINTHUS
ARBUTUS UNEDO
CYTISUS SCOPARIUS
QUERCUS PYRENAICA
PTERIDIUM AQUIL.
1
2
3

a)

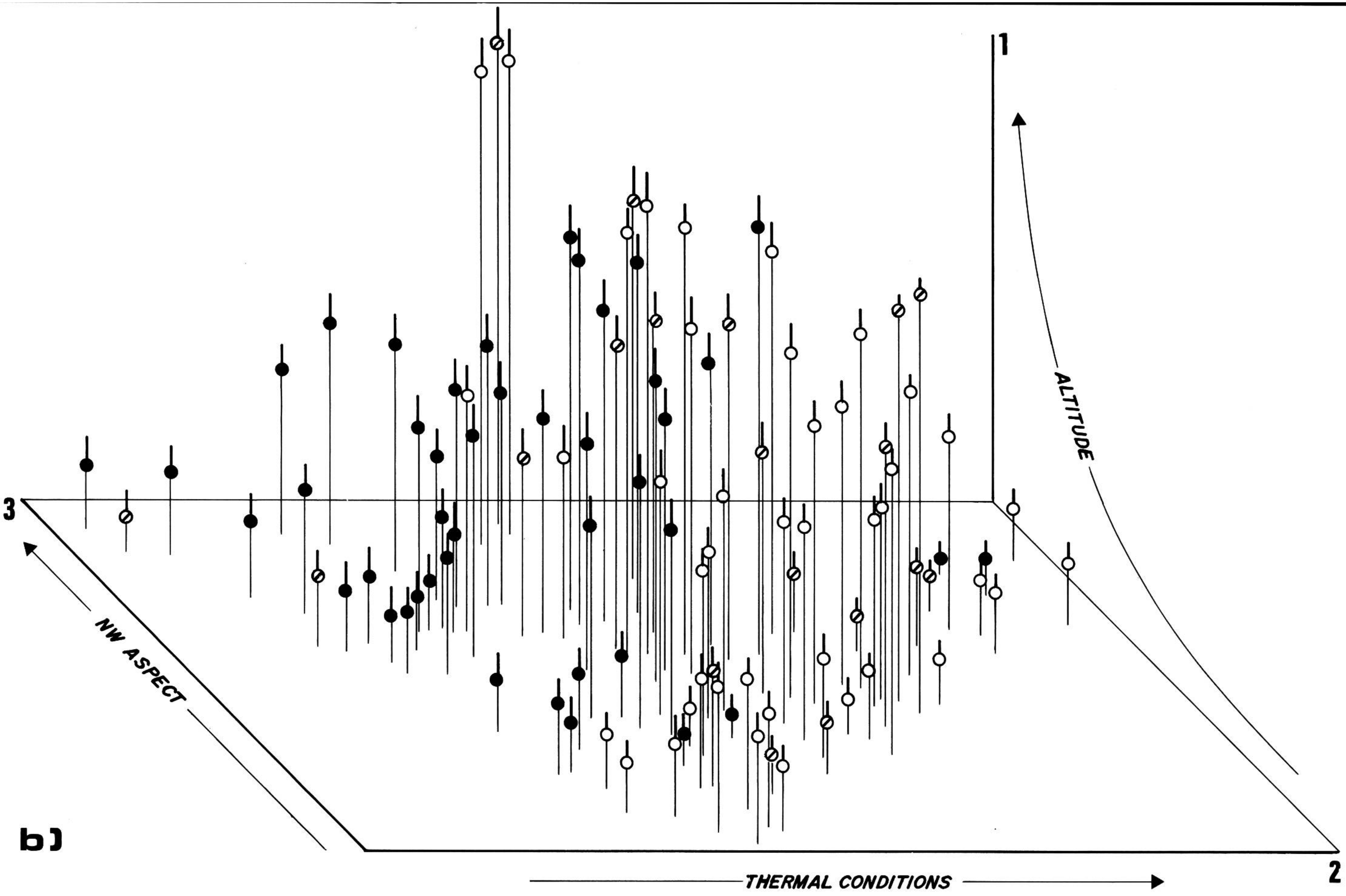


Fig. 2. — Location of sampling plots in the space defined by the main axes of the correspondence analysis of the floristic data. **a**, types of plant formations identified and characteristic species with high loadings in multivariate analysis; **b**, altitude values registered in sampling plots. Longitude of the small segments placed in circles corresponds, successively, to the height classes 300-550, 550-800, 800-1050, 1050-1300, 1300-1550, 1550-1800 asl. Aspect values: black circles N.W., white circles S.E., striped circles E./N.E. and W./S.W. (see Fig. 3). Multiple points are not included.

the interpretation of data from such a transect. Although its utilization was not completely rejected, the main objective of the study was considered to be the establishment of a preliminary classification of the woody vegetation.

A representative portion of the transition was chosen for study, the landscape of which could be interpreted through physiographical factors and those of anthropological land-use. The former were analysed in topographical, lithological and local climatic terms, and the latter reflected traditional management of such ecosystems. Both factors condition the presence of varied physiognomies superimposed on spatial variations dependent on vegetation adaptation to the physical environment.

Study objectives included: identification of the principal tendencies of spatial variation; environmental interpretation of such variations and the description of those communities forming part of the area's woody vegetation mosaic.

In this way the influence of certain -easily measured- conspicuous variables of the physical environment on vegetation distribution was evaluated, so that the groups of indicators and tendencies in variation automatically obtained could be expressed employing few factors.

Physiographical parameters were utilized to stratify the sample following sub-division (see later comments). However, the territory was studied from an integrated point of view, considering the landscape as a conjunction of land-systems, biotic, physical and anthropological components appearing interrelated. Physiognomical units equivalent to the land units of CHRISTIAN & STEWART (1968) or the "fatsiya" of VIKTOROV & al. (1962) were identified, allowing the regular distribution of sampling plots.

Geological sub-division was used to draw a map of units defined according to structural, lithological and textural affinities: 1. Granitic zones with porphyritic rocks, biotite and muscovite. 2. Metamorphic rocks with slate and shales. 3. Areas with siliceous sandstone outcrops. 4. Occasional outcrops of deep metamorphic rocks -migmatites, gneiss, feldspars.

A second, topographical, division allowed the identification of 4 zones related to altitude: 200-600 m, 600-1000 m, 1000-1400 m and 1400-1800 m above sea level (asl).

By superimposing the two divisions only 15 geomorphological sectors were identified in the study area, there being no areas over 1400 m in the Pre-Cambrian areas of geological sector 4.

Detailed field and photo-interpretation studies permitted the identification of 3 vegetation units according to the physiognomy and texture of the vegetation cover: dominant arboreal vegetation with *Quercus pyrenaica* Willd., *Quercus robur* L., *Castanea sativa* Miller and *Quercus rotundifolia* Lam.; dense thickets of matorral with *Erica australis* L. subsp. *aragonensis* (Wilk.) P. Court., *Cytisus scoparius* (L.) Link, *C. striatus* (Hill) Rothm. and *Cistus ladanifer* L. and open matorral of *Erica cinerea* L., *Erica umbellata* L., *Chamaespartium tridentatum* (L.) P. Gibbs, *Cytisus multiflorus* (H'Hern) Sweet and *Poligala mycrophylla* L. The distribution of this type of vegetation in the 15 geomorphological sectors identified allows the differentiation of a total of 32 strata.

Within each one of these regular sampling was undertaken in 4 to 8, 10 × 10 m plots placed at equal distances along the average contour of the strata (PINEDA & al., 1978). Occasionally, when the slope's geomorphological dynamics caused variation in the vegetation due to the export-accumulation gradient (BERNÁLDEZ & al., 1980), the parcels were placed down the slope, this information considered to be of great interest (see BEROUTCHACHVILI & MATHIEU, 1977).

A total of 132 parcels were studied. In each presence-absence data of 60 woody and certain herbaceous species noticeable for their abundance or biomass were collected. Data was also collected concerning: lithology (in a qualitative form); altitude in meters asl; slope in %; aspect, in degrees of deviation from a N-S axis, (PINEDA & BERNÁLDEZ, 1975; these parameters have proved efficient in the description of matorral habitats in areas of similar characteristics studies by those authors).

The matrix of biological information was analysed through multivariate correspondence analysis (CORDIER, 1965; BENZECRI, 1973) and the coordinates of parcels and species were projected into the planes defined by the principal axes calculated.

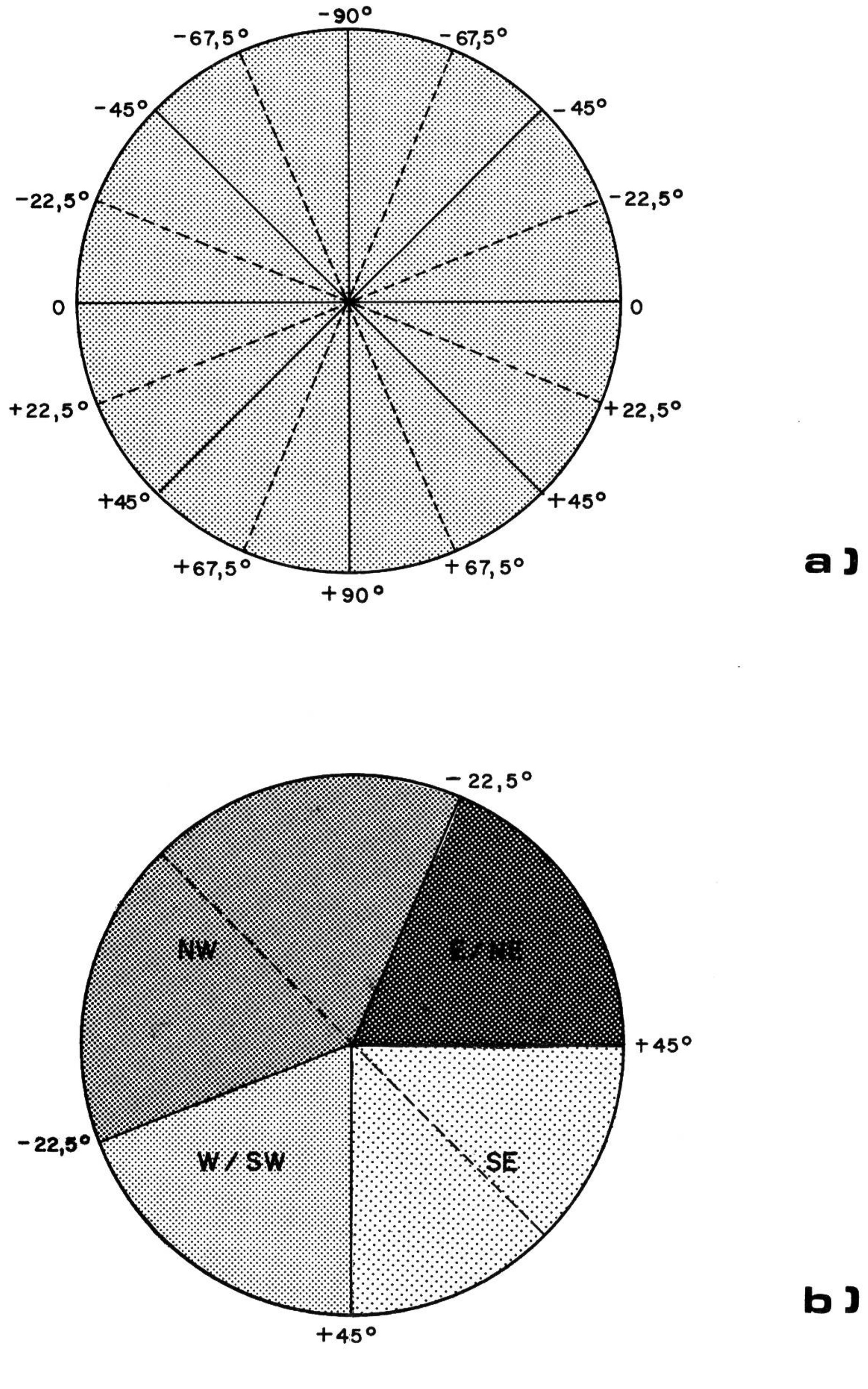


Fig. 3. — Reference scale for measuring aspect in sampling plots. The classes listed in Figure 2 correspond to the sections represented in b.

Table 1. — Classification of the plant communities identified using correspondence analysis of biological data collected and environmental interpretation.

Type	*Species most contributing to define axes of analysis*	*Associated environmental factors*
A. Shrub communities		*Altitude:* very variable.
Axes 1 & 3:	*Charaespartium tridentatum** (L.) P. Gibbs.	*Aspect:* no predominant ten-
	Erica australis subsp. *aragonensis** Willk.	dency.
	*Erica umbellata** L.	*Slope:* very variable.
	Halimium alyssoides (Lam.) C. Koch	*Lithology:* granites, sand-
	*Halimium umbellatum** (L.) Spach	stones and shales.
	*Tuberaria globularifolia** (Lam.) Willk.	
1. Thermophyllous shrubs		*Altitude:* under 550 m.
Axis 1:	*Cistus ladanifer** L.	*Aspect:* S.
	Genista hystrix Lange	*Slope:* 40-60%.
	Halimium umbellatum (L.) Spach	
2. Orophyllous shrubs		*Altitude:* over 1500 m.
Axes 1 & 3:	*Genista obtusiramea* Gay ex Spach	*Aspect:* S.-S.E.
	Vaccinium myrtillus L.	*Slope:* 20-40%.
		Lithology: sandstones and
		granites.
2. Mesophytic shrubs		*Altitude:* medium & high over
Axis 1:	*Erica australis* subsp. *aragonensis* Willk.	600 m.
	Erica umbellata L.	*Aspect:* not defined.
	Halimium alyssoides (Lam.) C. Koch	*Slope:* variable.
		Lithology: granites and shales
B. Forest communities of perennial woodlands		*Altitude:* under 550 m.
Axis 2:	*Pistacia terebinthus* L.	*Aspect:* tendency for S.E.
	*Quercus rotundifolia** Lam.	orientation.
	*Rubia peregrina** L.	*Slope:* 40-60%.
	Arbutus unedo L.	*Lithology:* granites and shales
	Ruscus aculeatus L.	
	Cistus psilosepalus Sweet	
	Cistus salviaefolius L.	
	Daphne gnidium L.	
	*Erica scoparia** L.	
	*Fraxinus angustifolia** Vahl	
	Helichrysum stœchas (L.) Moench	
	Osyris alba L.	
	Phillyrea angustifolia L.	
	Tamus communis L.	
	Lavandula stœchas subsp. *sampaniana*	
C. Forest communities of deciduous woodlands		*Altitude:* 500-1500 m.
Axes 1 & 2:	*Quercus pyrenaica* Willd.	*Aspect:* predominantly N.W.
	*Quercus robur** L.	*Slope:* very variable.
	*Sorbus aucuparia** L.	*Lithology:* all types appear-
	*Betula celtiberica** Rothm. & Vasc.	ing in area
	Teucrium scorodonia L.	
	Cytisus scoparius L.	
	Clinopodium vulgare L.	
	*Corylus avellana** L.	
	*Dryopteris filix-mas** (L.) Schott.	
	*Frangula alnus** Miller	
	*Ilex aquifolium** L.	
	Prunus spinosa L.	
	Pteridium aquilinum (L.) Kuhn.	
1. Atlantic woodlands		*Altitude:* 1000-1500 m.
Axis 2:	*Betula celtiberica* Rothm. & Vasc.	*Aspect:* predominantly N.W.
	*Corylus avellana** L.	*Slope:* very variable.
	*Dryopteris filix-mas** (L.) Schott.	*Lithology:* shales and sand-
	Ilex aquifolium L.	stones.
	Quercus robur L.	
	Sorbus aucuparia L.	
	Vaccinium myrtillus L.	

2. Sub-Mediterranean woodlands
Axis 1: *Cytisus scoparius* (L.) Link
Pteridium aquilinum (L.) Kuhn.
Quercus pyrenaica Willd.

Altitude: 1000-1500 m.
Aspect: variable, certain N.W. predominance.
Lithology: very variable, mainly granite, shales and sandstones.

[1]Species marked by an * only appear in the groups of parcels shown in Fig. 2.

Results and discussion

Figure 2a is a three-dimensional representation of the multivariate analysis in which only those coordinates of the sampling plots are shown. Those species of most importance in each axis are noted at the end of each axis to simplify the figure (see Table 1).

From the upper to the lower part of the figure two groups of parcels can be differentiated, arranged according to the first axis obtained. These groups correspond to matorral (high coordinates in the first axis) and woodlands (low coordinates) respectively. The importance of the species in this axis enables the identification of notably differing communities along it. No arboreal species presents high coordinates in this axis, all being concentrated in its lower section. Nevertheless, from left to right two extremes of woodland types can be identified, according to the species loadings in the second axis.

A similar pattern can be identified in the upper part of the figure in the matorral communities, which are, however, less clearly segregated. From the inner to outer parts of the figure a third type of woodland and matorral may also be identified along axis 3, both of an intermediate nature.

Figure 2b represents the correspondence between the classification of the floristic data described above and the value of two of the abiotic parameters measured in the parcels. Of these parameters, neither the lithological classes nor the slope position of the plots offered regularity in the spatial distribution defined by the axes and only altitude and aspect allowed the identification of tendencies of variation in this space. Altitude was well shown in axes 1 and 2 and aspect between 2 and 3. However neither of these two factors presented a clear tendency in any of the three axes. The correlation coefficient calculated between the parcel coordinates in the first axis and the values of altitude, presented a significant but low value ($r = 0.48$, $p \leqslant 0.01$). The same was true for the second axis. As far as aspect was concerned, highest segregation between parcels studied was obtained by differentiating the value of such parcels in degrees of deviation from a N-S axis (Fig. 3). The correlations obtained for each axis were low ($r = 0.35$, $p \leqslant 0.01$ for the second axis and $r = 0.38$, $p \leqslant 0.01$ for the third), but the segregation is clear in the three dimensional model.

It should be noted that if the correspondence between the parcels' floristic composition and variation of a given environmental factor reflects a non-linear relation, then interpretation of the axes of the multivariate analysis through simple correlation may not suffice. This procedure, frequently employed since VAN GROENEWOND (1965) and GITTINS (1969) until the present day, has received criticism from several authors (NOY-MEIR & AUSTIN, 1970; AUSTIN & NOY-MEIR, 1971; BERNÁLDEZ & al., 1972; RAMÍREZ & al., 1976). Interpretation of the environmental variability underlying the biocenotic structure identified, may be undertaken using a stochastic correlation instead of a linear one, equivalent to the graphic analysis undertaken here (PINEDA & al., 1978).

The S.E.-N.W. contrast and altitudinal variation, are factors capable of explaining the tendency in floristic variation in the area studied. The general aspect of the area and its location in the N.W. of the Iberian Peninsula between areas dominated by Mediterranean and Atlantic factors, favours this contrast. Northwest facing slopes are more directly influenced by Atlantic humidity, as opposed to south facing slopes, which are drier and present a continental character.

Human landuse factores are superimposed on this picture. Vegetation exploitation gives rise to erosion processes which are accentuated in south and east facing slopes. On these slopes erosion of fertile soils following deforestation is quicker and the successional evolution of soil "biostasis" recuperation is slow if the bio-geo-edaphic equilibrium is broken. The same phenomenum has been observed in other, similar situations, where floristic changes associated to "biostasis" and "rhexistasis" in sunny and shaded slopes has been studied (LEVASSOR & al., 1981), or soil erosion

(SASTRE & al., 1982). In the arrangement of parcels from matorral to woodland communities along the first axis (Fig. 2), the existence of Mediterranean woodlands is more common on S.E. facing slopes, a tendency also noted in sub-Mediterranean woodlands, but not in Atlantic ones (Fig. 2b).

A gradual gradient in thermal conditions along the second axis is also observed, where sub-Mediterranean woodlands and mesophytic matorral appear in intermediate positions. This axis probably reflects the variation of a thermal related factor not used as such in the study.

Table 1 represents a classification of the plant communities detected with the aid of the analysis, and of the non-human environmental factors that appeared to be associated. The main variation identified in the vegetation also reflected the different land use options historically affecting the area (MORLA-JUARISTI, 1984). The existing mosaic of matorral and woodland represents a reduction in the former wooded area and a spread of the matorral formations. In the latter, traditional periodical burning and clearing for pasturage purposes have prevented evolution towards forest communities, a phenomenum well known in many areas of similar characteristics (MaB, 1979; FROMENT, 1981). Within the classification of matorral and woodland there are also numerous transition communities, badly represented in the analysis, that reflect different types of direct human influence. Amongst these are *Cytisus scoparius, C. multiflorus* and *Genista polygaliphylla* which colonize deep, fertile, previously cultivated soils, and *Ulex europaeus* formations ("tojares"), favoured from the eighteenth century for the manufacture of organic fertilisers (CABO ALONSO, 1964; BOUHIER, 1979) and currently prevalent in certain areas due to its characteristic resistence to fire.

Conclusions

Analysis of the information gathered in 32 sampling plots allowed a simplification of the vegetation classification studies in terms of environmental factors of a local climatic nature. These relate to the 6 different vegetation formations to which the original information was reduced.

Two factors were responsable: altitude and slope aspect with respect to a N.W.-S.E. axis. Values of these two parameters reflect poles of variation shown by clearly differing types of vegetation. Altitude contributes to the differention of woodland and matorral communities and aspect corresponds to a Mediterranean-oceanic variation similar to that noted by other researchers (RIVAS-MARTÍNEZ, 1963; PINEDA, 1975) in other mountain areas in the Iberian Peninsula. Not all floristic variation is explained by these factors unless other factors related to past traditional landuse are taken into consideration.

Altitude and slope aspect characteristically reflect the dominant influence of ambient temperature (altitudinal lowering in temperature, contrast sunny-shaded slope) and water availability (rainfall and windward/föhn contrasts). Other abiotic parameters considered, of little or no climatic character, do not explain the difference between the Mediterranean and Atlantic environments studied. Lithology and declivity of slope vary greatly in the area studied, both in the mainly Atlantic north-western area and the Mediterranean south-eastern part, in such a way that the boundary studied does not appear to play a dominant role. Although slope and aspect play an important role in the soil's thermal balance, they are not differentiating factors in this case. The influence of aspect could be more related to phenomena of atmospheric circulation than to insolation. This could be confirmed by the dominant (N.W.-S.E.) trend of floristic variation, equivalent to dominant winds in the area and not to the more typical sunny slope/shady slope (N.-S.) contrast.

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