Cryptogamie, Mycologie, 2003, 24 (1): 73-97

Threatened lichens in central Spain (saxicolous species excluded)

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Abstract – The current conservation status of lichens and some non-lichenized fungi in central Spain, a vast territory of 80,000 km^2 is analysed. A list of 88 lichens is presented and species are classified following IUCN categories and criteria. Some of these criteria are modified to overcome the difficulties that arise when these threat categories are applied to these organisms. Sixteen species are classified as regionally Critically Endangered, 24 as Endangered and 48 as Vulnerable. Most of them are epiphytes (85%), probably because other lichen elements have been poorly studied in the territory. The main threats affecting these lichens are forest management activities and fire because the main habitats for threatened lichens are deciduous and sclerophyllous forests. Information covering different features of lichens belonging to Critically Endangered and Endangered is also included. Finally, several hotspots for endangered lichens in the territory are described and suggested as biodiversity conservation reserves.

Threatened lichens / Conservation / Red List / Spain / IUCN categories

INTRODUCTION

Lichens have been widely and successfully used as bioindicators during the last three decades because of combinations of several inherent characteristics: long longevity, low dispersal potential, high sensitivity to environmental changes, minimal interaction with the substratum, widespread distribution and ease of identification during all seasons (Hawksworth & Rose 1976; Richardson 1992). However, there is an evident lack of information on the conservation status of these organisms. It is known that there are many habitats rich in lichens that are being destroyed (Thor 1995). Therefore, at least locally, some lichen populations must be reaching an endangered status as a result of severe habitat declines after

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man-induced and recurrent perturbations. Furthermore, only a small set of national red lists of lichens has appeared (see references in Thor 1995; Church *et al.* 1996; Thor 1999; Türk & Hafellner 1999), most of them as preliminary reports or covering small geographic areas (Skorepa & Norden 1984; Moseley & Groves 1990; Burgaz *et al.* 1994). There is no national red list for lichens in Spain, although some partial studies on endangered lichens have been made in some regions such as Galicia, which is located in the northwesternmost corner of Spain, (Carballal *et al.* 1999) and Comunidad Valenciana, in eastern Spain, (Atienza & Segarra 2000).

The main problem in preparing such a list comes from the geographical inconsistency of lichenological flora studies (or easy availability of data) which means there is a deep ignorance of the current status of many lichens in wide territories and gaps in our knowledge (Thor 1995).

The second difficulty arises when revised IUCN threat categories (IUCN, 1994) are applied to organisms such as lichens or bryophytes (Hallingbäck *et al.* 1998) and even to vascular plants (Keith 1997). But, what are these problems? As has been noted for bryophytes (Hallingbäck *et al.,* 1998), it is very difficult to determine population size because of the problem of what constitutes an 'individual' in lichens. In order to overcome this problem we can use a pragmatic definition, at least in the case of species whose thalli can be easily differentiated, such as foliose lichens, where continuous and conspicuous thalli are considered different individuals. Two other problems are related to the definition of population. So, the size and the demographic course (decline or not) can be assessed only by means of monitoring (Church *et al.,* 1996) and there is an almost complete lack of this type of information.

Despite all these difficulties, we believe that there is a clear need to detect those lichens that are threatened in order to improve conservation management strategies. It is evident that there is no quantitative information on the decline of these populations apart from our field experience. However, we feel that the current demographic status of most lichens may be inferred from the habitats they exploit. Thus a combination between a profound floristic knowledge of these biodiversity elements and their habitats may be an efficient tool to determine the current conservation status of lichen species. So, following this approach we overcome, at least partially, the difficulties of risk classification based only on expert information (Mace & Lande 1991; Rohlf 1991). In any case, this type of red list of poorly studied organisms is defensible in the face of the challenge of global biodiversity conservation.

With this in mind we have prepared a red list for lichens and some non-lichenized fungi in Central Spain, a vast region for which we have a good floristic knowledge. It is also suggested what habitats are critical for these threatened species and what are the recognized threats concerning their future viability. Finally, we have recommended some local hotspots for protection of the most endangered lichen populations.

MATERIAL AND METHODS

Study area

Castilla-La Mancha is a large region in central Spain of ca. 80,000 km^2 (Fig. 1). This autonomous region presents a remarkable heterogeneity from geomorphological and climatical points of view and consequently a high landscape diversity. The area is extensively characterized by many mountain ranges, such as

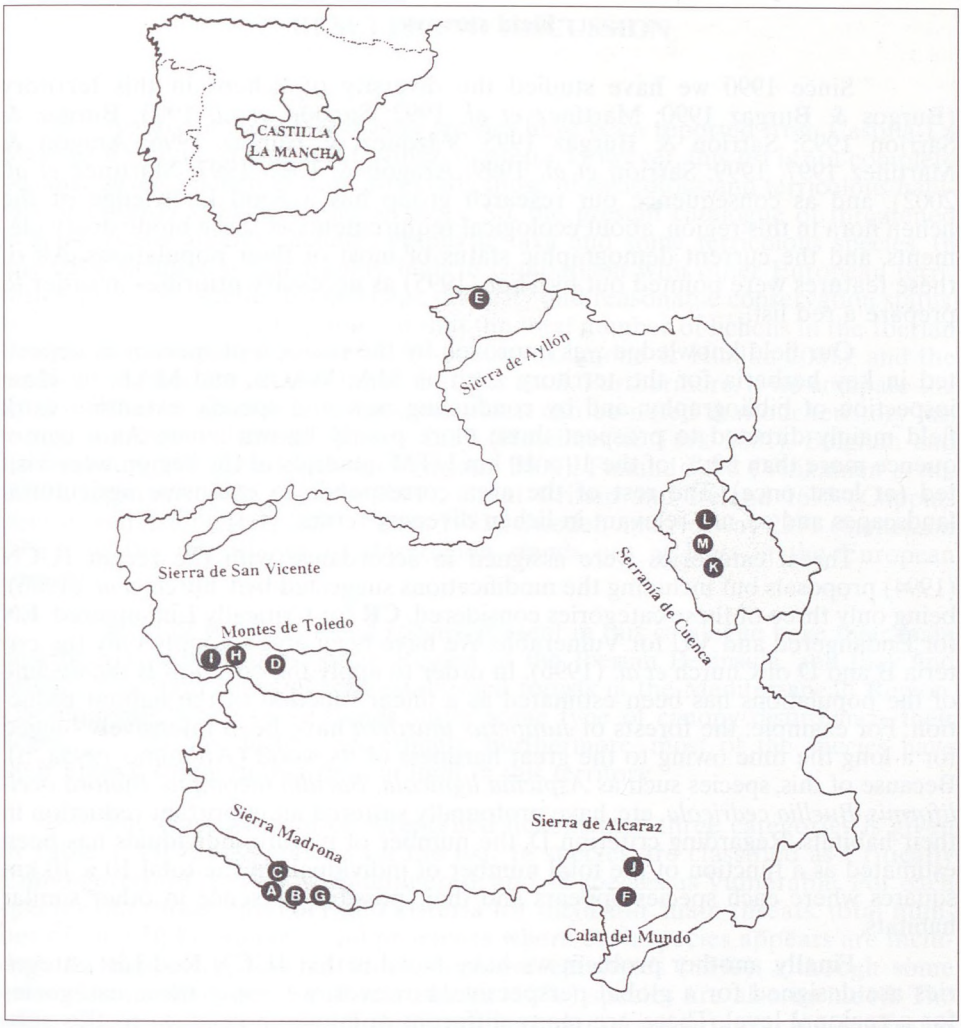

Fig. 1. Location of Castilla-La Mancha region in the Iberian Peninsula and situation of proposed areas for conservation (A-M).

Sierra de San Vicente, Sierra de Ayllón where the highest point of the territory is reached (2,300 m), Sistema Ibérico, Sierra de Alcaraz, Sierra Madrona and Montes de Toledo. Most of these encircle a relatively high plateau that reaches 600 m on average. On the other hand, a great variability in geological substrata is also found (Anónimo 1991). Obviously this landscape variability determines the existence of different vegetation types which extend over meso-, supra- and oromediterranean bioclimatological belts (Rivas-Martínez 1987). The most conspicuous forest systems are dominated by contrasting tree species such as *Fagus sylvatica, Juniperus thurifera, Pinus halepensis, P. nigra, P. pinaster, P. pinea, P. sylvestris, Quercus faginea, Q. ilex* subsp. *ballota, Q. pyrenaica,* and *Q. suber*. Furthermore, a complete set of unforested landscape units are also present.

Field surveys

Since 1990 we have studied the diversity of lichens in this territory (Burgos & Burgaz 1990; Martínez *et al.* 1992; Sarrión *et al.* 1993; Burgaz & Sarrión 1995; Sarrión & Burgaz 1995; Vázquez & Burgaz 1996; Aragón & Martínez 1997, 1999; Sarrión *et al.* 1999; Aragón & Rico 1997; Martínez *et al.* 2002), and as consequence our research group has a good knowledge of the lichen flora in this region, about ecological requirements of these biodiversity elements, and the current demographic status of most of their populations. All of these features were pointed out by Thor (1995) as necessary priorities in order to prepare a red list.

Our field knowledge was improved by the revision of specimens deposited in key herbaria for the territory, such as MA, MACB, and MAF; by close inspection of bibliography; and by conducting new and specific extensive work field mainly directed to prospect those more poorly known zones. As a consequence more than 60 % of the 10 × 10 km UTM quadrats of the region were visited (at least once). The rest of the area corresponds to extensive agricultural landscapes and so, not relevant in lichen diversity terms.

Threat categories were assigned in accordance with the recent IUCN (1994) proposals but including the modifications suggested by Church *et al.* (1996), being only three of these categories considered, **CR** for Critically Endangered; **EN** for Endangered and **VU** for Vulnerable. We have been able to apply only the criteria B and D of Church *et al.* (1996). In order to apply the criterion B the decline of the populations has been estimated as a linear function of the habitat reduction. For example: the forests of *Juniperus thurifera* have been intensively logged for a long the time owing to the great hardness of its wood (Anónimo 1995a, b). Because of this, species such as *Aspicilia lignicola, Bacidia incompta, Biatora ocelliformis, Buellia cedricola*, etc. have profoundly suffered an important reduction in their habitats. Regarding criterion D, the number of mature individuals has been estimated as a function of the total number of individuals in the total 10 × 10 km squares where each species appears and their possible presence in other similar habitats.

Finally, another problem we have faced is that IUCN Red List categories are designed for a global perspective, however, we apply these categories for a regional level. There are many different opinions in relation to this subject, but following Hallingbäck *et al.* (1998) there are not any problems in applying these categories at regional level. The IUCN category system evaluates the risk of extinction of a population within a geographical region, but this region can be the world, a country or a region. In this sense, we not can forget that these categories are at regional level, and they can change to another different level.

The main threats that affect the lichen species are indicated in Table 1 by means of a number. This is in accordance with the major threat types used in the documentation of the 2000 Red List (http://www.redlist.org): **1**, overgrazing; **2**, timber plantations; **3**, logging/forest management activities; **4**, firewood and charcoal production; **5**, tourism; **6**, deforestation; **7**, firecuts construction; **8**, fires; **9**, drought; **10**, recreational activities (mainly motorcycling); **11**, slash and burn activities or other silvicultural procedures.

For the nomenclature of the species we follow Purvis *et al.* (1992), Nimis (1993) and Llimona & Hladún (2001).

RESULTS AND DISCUSSION

Approximately, 900 lichens species have been reported from Castilla-La Mancha Region (Aragón & Martínez, in prep.). However, this list is not complete because several lichen groups, especially those of saxicolous and terricolous habitats are poorly studied in the territory. So, the present catalogue of threatened lichens species mainly includes epiphytic taxa and some terricolous species. In any case, richness is remarkably high in comparison with other European territories, probably due to its landscape diversity and reasonable conservation status. Besides, it is necessary to point out that the total number of lichens in the Iberian Peninsula is estimated at over 2,500 species (Llimona & Hladún 2001), and the studied area has almost one third of at this total. Furthermore, if we compare the total number of species in other countries, it can be noted that our territory has a high number of lichens: Austria 2237 (Hafellner & Türk 2001), Belgium and Luxembourg 909 (Diederich & Sérusiaux 2000), Finland 1458 (Vitikainen *et al.*, 1997), Germany 1835 (Scholz 2000), Great Britain and Ireland 1675 (Coppins pers. comm. 2001), Italy 2200 (Nimis 1993), Sweden and Norway 2271 (Santesson 1993), so the importance of this region stands out at least in the European context.

Most of the threatened species present in this catalogue have their main distribution in the Eurosiberian Region of the Iberian Peninsula, and they find refugia in certain zones of well-established forests in the Mediterranean Region. Consequently, when these stands suffer some type of canopy disturbance, their lichen populations decline accordingly. Furthermore, most of the species have their known southern distribution limit in this territory.

The classification of threatened lichens into three categories is given in Table 1. Of the 88 species on the list, 16 species are classified as Critically Endangered, 24 species as Endangered, and 48 species as Vulnerable. For each species the threat category and criteria for inclusion, main threats, total number of 10×10 km squares and provinces where each species appears are included. As expected, most of the lichens are epiphytes (85%), although some critical saxicolous (4%) and terricolous (12%) species are also included. The main threats affecting these lichens are, in order of importance: logging/forest management activities (affecting 72 species), fires (affecting 32 species), firewood and charcoal production (affecting 31 species), drought (affecting 25 species), firecuts construction (affecting 19 species), tourism (affecting 12 species), recreational activities (affecting 12 species), overgrazing (affecting 7 species), slash and burn activities or other sylvicultural procedures (affecting 3 species), timber plantations (affecting 1 species), and deforestation (affecting 1 species).

The main threat in our territory is logging/forest management activities. The relevance of forest management is mainly because the most threatened species in our territory are epiphytes and they are highly dependent on the existence of a closed and undisturbed forest canopy. This problem mainly concerns deciduous woodlands, but also pine and juniper forests. Another clearly related problem is the cutting of old-growth trees and especially dead trees to minimize the risk of trees diseases and the fuel load of managed forests. These trees support and shelter many threatened lignicolous lichens.

Table 1. List of threatened lichen and non-lichenized fungi species in alphabetical order, indicating the threat category and criteria for inclusion, main threats, total number of 10 × 10 km utm squares and provinces where each species appears between parenthesis (AB: Albacete; CR: Ciudad Real; CU: Cuenca; GU: Guadalajara; TO: Toledo). Threats: **1**, overgrazing; **2**, timber plantations; **3**, logging/forest management activities; **4**, firewood and charcoal production; **5**, tourism; **6**, deforestation; **7**, firecuts construction; **8**, fires; **9**, drought; **10**, recreational activities (mainly motorcycling); **11**, slash and burn activities or other sylvicultural procedures.

Species	*Category*	*Criteria*	*Threats*	*Total number of 10 km × 10 km squares*
Acrocordia cavata	CR	D	6, 9	1 (AB)
Agonimia allobata	EN	B, D	3, 4, 9	2 (CR)
Agonimia octospora	VU	D	3, 4, 9	15 (CR, TO)
Aspicilia lignicola	CR	B, D	3	2 (CU)
Bacidia absistens	CR	B, D	3, 8	1 (CR)
Bacidia incompta	EN	B, D	3	2 (CU)
Biatora ocelliformis	CR	B, D	3	1 (CU)
Bryoria capillaris	VU	B, D1	3, 7, 8	6 (CU, GU)
Bryoria implexa	VU	B, D1	3, 7, 8	7 (AB, CU)
Buellia cedricola	VU	B, D	3, 8	9 (AB, CR, CU, TO)
Calicium lichenoides	VU	B, D1	3, 7, 8	10 (AB, CR, CU, GU, TO)
Calicium montanum	EN	B, D	3, 8	4 (CR, TO)
Catinaria atropurpurea	EN	B, D	3, 4, 9	5 (AB, CR, TO)
Catinaria montana	CR	B, D	3, 9	1 (CR)
Cetraria crespoae	VU	D	8, 11	4 (CR, GU, TO)
Cetraria merillii	VU	D1	8, 11	7 (CR, GU, TO)
Cetraria sepincola	EN	D	3, 7, 8	2 (GU)
Cetraria steppae	VU	D	1, 10	6 (CU, GU)
Chaenotheca furfuracea	VU	B, D1	3, 7, 8	7 (AB, CU, GU)
Chaenotheca phaeocephala	EN	D	3, 7, 8, 9	5 (AB, CR, CU)
Chaenotheca trichialis	EN	D	3, 7, 8, 9	3 (AB, CU)
Chaenotheca xyloxena	EN	D	3, 7, 8, 9	2 (CU)
Chaenothecopsis pusilla	EN	B, D	3	2 (TO)
Cladina arbuscula	VU	D1	5, 10	4 (GU)
Cladonia cenotea	EN	D	3, 7, 8	2 (CU)
Cladonia cryptochlorophaea	VU	D1	1, 5, 10	4 (GU)
Cladonia furcata	VU	B, D1	3, 8	7 (CR, GU)
Cladonia iberica	EN	D	5, 10	3 (CR)
Cladonia incrassata	VU	B, D1	3, 8	6 (CR, TO)
Cladonia squamosa	VU	B, D1	3, 4	6 (CR, TO)
Cladonia subrangiformis	VU	B, D1	1, 5, 10	7 (CU, GU)
Cladonia symphycarpa	VU	B, D1	1, 5	7 (CU, GU)

Species	*Category*	*Criteria*	*Threats*	*Total number of 10 km × 10 km squares*
Collema fasciculare	VU	B, D1	3, 4	7 (AB, CR, TO)
Collema flaccidum	VU	B, D1	3, 4	8 (AB, CR, TO)
Collema nigrescens	VU	B, D1	3, 4	10 (AB, CR, CU, GU, TO)
Collema subflaccidum	VU	B, D1	3, 4	7 (AB, CR, TO)
Collema subnigrescens	VU	B, D1	3, 4	8 (AB, CR, TO)
Cyphelium inquinans	CR	D	3, 7, 8, 9	2 (AB)
Cyphelium notarisii	CR	D	3, 7, 8, 9	1 (CU)
Cyphelium tigillare	VU	B, D1	3, 8	10 (AB, CR, GU, TO)
Degelia atlantica	VU	B, D	3, 4, 9	6 (AB, CR, TO)
Degelia plumbea	VU	B, D1	3, 4	10 (AB, CR, GU, TO)
Gyalecta ulmi	EN	B, D	3, 9	4 (AB, CU)
Hypocenomyce anthracophila	EN	D	3, 7, 8, 9	3 (AB, CU)
Koerberia biformis	VU	B, D	3, 4	10 (AB, CR, TO)
Lecidea hypopta	EN	D	3, 7, 8	2 (AB, CU)
Leptochidium albociliatum	VU	B, D1	3	7 (CR, CU, GU)
Leptogium saturninum	VU	B, D1	3, 4	11 (AB, CU, CR, TO)
Letharia vulpina	EN	B	3, 7, 8	3 (CU, GU)
Lobaria amplissima	VU	B, D	3, 4, 9	7 (CR, GU, TO)
Lobaria pulmonaria	VU	B, D1	3, 4, 9	10 (AB, CR, GU, TO)
Lobaria scrobiculata	VU	B, D1	3, 4, 9	12 (AB, CR, GU, TO)
Megalaria grossa	VU	B, D1	11	6 (CU, GU)
Megalaria laureri	CR	B, D	3, 9	1 (TO)
Melaspilea urceolata	CR	B, D	3, 9	1 (AB)
Microcalicium disseminatum	CR	D	3, 7, 8, 9	1 (CU)
Moelleropsis nebulosa	EN	B, D	3	2 (CR)
Mycobilimbia berengeriana	VU	B, D1	3, 4	8 (AB, CR, TO)
Mycobilimbia hypnorum	VU	B, D1	3, 4	6 (AB, CR, TO)
Mycocalicium victoriae	EN	B, D	3, 4	2 (CR)
Nephroma parile	CR	B, D	2, 3, 9	1 (GU)
Nephroma resupinatum	EN	B, D	3, 4, 9	3 (CR, GU, TO)
Pannaria conoplea	CR	B, D	3, 9	1 (CR)
Pannaria ignobilis	VU	B, D1	3, 4	12 (AB, CR, CU, TO)
Pannaria olivacea	EN	B, D	3, 8	3 (CR, TO)
Pannaria pezizoides	EN	B, D	3, 4	2 (GU, TO)
Pannaria rubiginosa	VU	D1	3, 4	6 (AB, CR, TO)
Parmelia submontana	VU	B, D1	3, 4	8 (AB, CU, GU, TO)
Parmeliopsis hyperopta	VU	B, D1	3, 7, 8	8 (AB, CU, GU)
Parmotrema chinense	VU	D1	3, 4	5 (CU, CR, TO)

Species	*Category*	*Criteria*	*Threats*	*Total number of 10 km × 10 km squares*
Peltigera horizontalis	EN	B, D	3, 4, 9	6 (CR, GU, TO)
Peltigera monticola	VU	D	5, 10	6 (AB, CU, GU)
Peltigera venosa	EN	D	5, 10	1 (GU)
Pertusaria ophthalmiza	VU	D1	3, 7, 8	5 (AB)
Pertusaria paramerae	VU	B, D1	3, 7, 8	10 (AB, CU)
Protoparmelia oleagina	CR	D	3, 8	1 (CR)
Psoroma hypnorum	CR	D	5, 10	1 (GU)
Rinodina dalmatica	EN	B, D	3, 4	2 (CR)
Rinodina griseosoralifera	CR	B, D	3, 4, 9	1 (TO)
Solorina bispora	CR	D	1, 5, 10	1 (AB)
Sphaerothallia fruticulosa	VU	B, D1	1, 5, 10	6, (CU, GU)
Sphaerothallia hispida	VU	B, D1	1, 5, 10	7 (CU, GU)
Strangospora microhaema	EN	B, D	3, 4, 9	2 (CR)
Usnea fulvoreagens	VU	B, D1	3, 4, 9	6 (CR, GU)
Vulpicida pinastri	VU	D1	3, 7, 8	4 (GU)
Waynea adscendens	VU	B, D1	3, 4	14 (AB, CR, CU, TO)
Xanthoparmelia vagans	VU	B, D1	5, 10	8 (CU, GU)
Xylographa abietina	VU	D1	3, 8	5 (CU, GU)

THREATENED LICHENS LIST

Acrocordia cavata (Ach.) R.C. Harris – Critically Endangered
This species grows exclusively on the trunks of some isolated endemic maples (*Acer granatense*) together with *Bacidia rosella* and *Opegrapha varia* in a very small stand in a steep ravine in Sierra de Alcaraz (Aragón & Martínez 1999), which is located in the southeasternmost tip of the region. In the Iberian Peninsula it is known only from few localities in the northern Eurosiberian fringe (Carballal *et al.* 1990; Etayo 1990a; Etayo & Gómez-Bolea 1992; Boqueras *et al.* 1993; López de Silanes *et al.*, 1999). In Europe this species prefers subatlanctic areas (Coppins & James 1978; Nimis 1993), and it is also known from North America where it is rather common (Harris 1973; Coppins & James 1978).

Agonimia allobata (Stizenb.) P. James – Endangered
This species grows in two well-preserved forest stands in Sierra Madrona on tree bases of old *Quercus ilex* subsp. *ballota* and *Q. pyrenaica* trees. Other notable lichens in the same community are *Dendriscocaulon umhausense, Leptogium teretiusculum, Lobaria scrobiculata, Nephroma laevigatum* and *Waynea adscendens*. In the Iberian Peninsula it is known only from eight localities in the northeast (Catalonia) and one other in the south (Cádiz province) (Longán & Gómez-Bolea 1998, 1999). Its world distribution area is restricted to the British Isles, Ireland, Switzerland and France (Purvis *et al,* 1992), Austria (Hafellner & Türk 2001),

Sweden (Santesson 1993), Ukraine (Kondratyuk *et al.* 1998), Luxembourg (Diederich & Sérusiaux 2000) and Michigan, USA (Fryday, 2001).

Aspicilia lignicola (Anzi) Hue – Critically Endangered
It has been found only on bark of very old junipers (*Juniperus thurifera*) and occasionally on lignum in two localities of Serranía de Cuenca (Martínez *et al.* 2002), comprising a very reduced set of thalli. It usually appears together with *Lecanora paramerae, Pertusaria albescens* and *P. paramerae*. In Spain it was previously reported only from Cáceres province (Fos 1998), although close inspection of this specimen showed the absence of spores (G. Aragón) and consequently its determination is doubtful. The only known records in the world are from the Alps (Ozenda & Clauzade 1970; Nimis 1993; Hafellner & Türk 2001), and from North Africa (Nimis 1993).

Bacidia absistens (Nyl.) Arnold – Critically Endangered
We have detected a very small population in the mesomediterranean belt of Sierra Madrona. The individuals appear on bark of old *Juniperus oxycedrus*, which occurs under the canopy of *Quercus ilex* subsp. *ballota* trees. Associated lichens are *Leptogium teretiusculum, Nephroma laevigatum, Pannaria mediterranea, P. olivacea* and *Waynea adscendens*. In the Iberian Peninsula it has been reported from a few localities in the northwest of Spain (Carballal & Álvarez 1994) and from Portugal (Tavares 1944; Jones 2000). In Europe this species has a subatlantic distribution from the south of the Scandinavian Peninsula to the British Isles (Purvis *et al.*, 1992; Nimis 1993). Also known from Pacific west coast of North America (Ekman 1996).

Bacidia incompta (Borrer ex Hook.) Anzi – Endangered
This epiphyte has been detected only in two small populations located in Serranía de Cuenca (Martínez *et al.*, 2002), growing on bark of isolated and old junipers (*Juniperus thurifera*). Other rare lichens of the corresponding community are *Gyalecta ulmi* and *Waynea adscendens*. In the Iberian Peninsula it is known only from the north of Spain (López de Silanes *et al.* 1999; Etayo 1990b) and from Portugal (Boom *et al.* 1990). Its world distribution area is confined to Europe (Purvis *et al.*, 1992; Nimis 1993); records from North America are erroneous (Ekman 1996).

Biatora ocelliformis (Nyl.) Arnold – Critically Endangered
This extremely endangered lichen has a unique population in the Iberian Peninsula comprising a very small number of individuals (Martínez *et al.*, 2002). This location is a *Juniperus thurifera* forest in Serranía de Cuenca, where its thalli colonize lignum of very old trees. It grows together with *Buellia cedricola, Cyphelium tigillare, Lecanora saligna* and *Pertusaria paramerae*. It is confined to Europe, mainly in the centre and in the north, with the French Pyrenees being hitherto its southern known distribution limit (Printzen 1995).

Calicium montanum Tibell – Endangered
This species is found in four localities, two in Sierra Madrona (Burgaz & Sarrión 1995, as *Calicium parvum*) and two others in Montes de Toledo (Aragón & Martínez 1997, as *Calicium* sp.) on lignum of *Juniperus oxycedrus* and *Quercus pyrenaica* in humid environments together with *Buellia cedricola, Cyphelium tigillare, Lecanora varia* and *Pyrrhospora elabens*. In the Iberian Peninsula it is known only from these localities. Until recently it was thought to be restricted to Europe, and known only from Germany, Italy, Portugal and Spain (Tibell 1999), but it has recently been identified from Arizona, USA (Kolb & Spribille 2001).

Catinaria atropurpurea (Schaerer) Vezda & Poelt – Endangered
Although this species occurs in Calar del Mundo (Moreno *et al.,* 1985), Sierra Madrona and Montes de Toledo (Aragón & Martínez 1997), its presence in these localities is very scarce, comprising very few individuals. It is predominantly corticolous, growing on *Hedera helix* and *Arbutus unedo*, but may also colonize lignum of *Quercus pyrenaica* and *Q. ilex* subsp. *ballota*, together with *Collema subnigrescens, Lobaria amplissima, Normandina pulchella* and *Peltigera collina.* In the Iberian Peninsula it is known from La Coruña (Crespo *et al.* 1983), Gerona (Boqueras & Gómez-Bolea 1987), Navarra (Etayo & Gómez-Bolea 1992) and Salamanca provinces (Marcos 1986) in Spain, and from Portugal (Tavares 1950; Jones 2000). Elsewhere it is found in west Europe and North America (Purvis *et al.,* 1992).

Catinaria montana (Nyl.) Vainio – Critically Endangered
This extremely endangered species is found at only locality, in Sierra Madrona. This location is a well-preserved *Quercus pyrenaica* forests stand, where thalli colonize mossy bark and stumps. In the Iberian Peninsula it is known only from Teruel province in Spain (Atienza *et al.,* 1992) and from Portugal (Boom & Giralt 1999). Its world distribution area is restricted to the Iberian Peninsula and the French Pyrenees (Kalb 1982; Clauzade & Roux 1985).

Cetraria sepincola (Ehrh.) Ach. – Endangered
This lichen has been collected only in two small populations situated in Sierra de Ayllón, which constitutes its southern distribution limit in Spain (Martínez & Aragón 1996). It grows on bark of *Erica australis, Pinus nigra* and *P. sylvestris.* It is widely distributed in the Iberian Peninsula. It is a circumboreal species which reaches the Mediterranean mountains (Nimis 1993).

Chaenotheca phaeocephala (Turner) Th. Fr. – Endangered
It is known only from five localities, two in Calar del Mundo (Sarrión *et al.,* 1999), two in Sierra de Alcaraz (Aragón & Martínez 1999) and one other in Sierra Madrona (Sarrión *et al.,* 1999). It grows on bark of old phorophytes, such as *Pinus nigra, Juniperus thurifera* and *Alnus glutinosa.* The most frequent co-occurring species are: *Buellia cedricola, Chaenotheca chrysocephala, Ch. ferruginea, Ch. trichialis, Pertusaria albescens* and *P. paramerae.* In the Iberian Peninsula the species is reported only from Jaén (Sarrión *et al.* 1999) and Lugo provinces (Álvarez-Andrés *et al.* 1999) in Spain and from Portugal (Boom & Giralt 1999). This species is widely distributed in Europe, North America and Nepal (Tibell 1980; Nimis 1993).

Chaenotheca trichialis (Ach.) Th. Fr. – Endangered
This scarce species is known only from one locality in Calar del Mundo (Sarrión *et al.* 1999), one in Sierra de Alcaraz (Aragón & Martínez 1999) and one other in Serranía de Cuenca (Martínez *et al.,* 2002), where it rarely occurs on bark of old and large trees of *Juniperus thurifera* and *Pinus nigra,* but the number of individuals per population is constantly small. It usually grows together with *Chaenotheca chrysocephala, Ch. ferruginea, Ch. furfuracea, Ch. phaeocephala* and *Waynea adscendens.* It has an irregular distribution pattern in the Iberian Peninsula, being more frequent in the Eurosiberian Region where it grows on lignum of deciduous trees in well-established forests (Llenas 1910; Hladún 1984; Azuaga & Gómez-Bolea 1996; López de Silanes *et al.* 1999; Sarrión *et al.,* 1999). In the Mediterranean Region it is known from the studied area and from Jaén province (Sarrión *et al.,* 1999). *Ch. trichialis* is a common and widespread species in the Holarctic Kingdom, although it is also known from Africa, South America and Australasia (Tibell 1980; Nimis 1993).

Chaenotheca xyloxena Nádv. – Endangered
This species grows in two well-preserved forest stands in Serranía de Cuenca (Martínez *et al.,* 2002) on tree bases of *Pinus nigra.* Another notable lichen here is *Ch. furfuracea.* In Spain it is known only from two localities in the north (Tibell 1980; Hladún 1984). This species has its optimum in boreal areas, where it colonizes bark and lignum of coniferous trees. In Scotland, *Ch. xyloxena* is more often found on the lignum of decicuous trees, *Betula* and *Alnus*, although it is found on the lignum of *Pinus sylvestris* also. *Ch. xyloxena* is widely distributed in Europe, North America, Asia and New Zealand (Purvis *et al.* 1992).

Chaenothecopsis pusilla (Flörke) A. Schmidt – Endangered (non-lichenized fungus)
It is known only from two localities in Montes de Toledo (Aragón & Martínez 1997). It grows on lignum of very old *Arbutus unedo* trees, which occur under the canopy of *Quercus ilex* subsp. *ballota* trees. In Spain it is reported only from few localities in Cáceres (Martínez & Aragón 1998), La Coruña, Huesca, Málaga (Sarrión *et al.,* 1999) and Navarra provinces (Etayo 1990a), and in Portugal it is known only from Minho province (Sampaio 1970). *Ch. pusilla* lives in the warm regions of both hemispheres (Purvis *et al.,* 1992).

Cladonia cenotea (Ach.) Schaer. – Endangered
This species grows exclusively on tree bases of some *Pinus sylvestris,* together with *Cladonia coniocraea, C. glauca* and *C. macilenta,* in two old-growth pine forests in Serranía de Cuenca (Martínez *et al.,* 2002). It mainly has a northern distribution in the Iberian Peninsula (Burgaz & Ahti 1994), the Cuenca province being its southern distribution limit. *C. cenotea* is known from Europe, America and Asia (Purvis *et al.* 1992).

Cladonia iberica Burgaz & Ahti – Endangered
C. iberica is recorded only in three localities of Sierra Madrona, growing on siliceous soils under the canopy of *Quercus ilex* subsp. *ballota* trees. Its world distribution area is restricted to the western Iberian Peninsula (Burgaz & Ahti 1994; Burgaz *et al.* 1999; Terrón-Alfonso *et al.* 2000).

Cyphelium inquinans (Sm.) Trevisan – Critically Endangered
This species exclusively colonizes bark of *Pinus nigra,* growing together with *Calicium viride, Chaenotheca chrysocephala, Ch. ferruginea* and *Ch. trichialis.* It is recorded only in two well-preserved pine stands, one in Sierra de Alcaraz (Aragón & Martínez 1999) and the other in Calar del Mundo (Sarrión *et al.,* 1999). In the Iberian Peninsula it is reported only from Jaén (Sarrión *et al.,* 1999), Lugo (Alvarez *et al.,* 1999) and Navarra provinces (Etayo 1990b) in Spain, and it is also known from Portugal (Sampaio 1970; Boom & Giralt 1999). Its world distribution area ranges from the Scandinavian Peninsula to the Mediterranean mountains, the British Isles, South America and New Zealand (Tibell 1987).

Cyphelium notarisii (Tul.) Blomb. & Forss.-Critically Endangered
We have detected only a very small population in the supramediterranean belt of Serranía de Cuenca. The individuals grow on tree bases of *Pinus pinaster* together with *Micarea denigrata.* It is a continental species, growing as isolated and reduced populations in the centre of Spain and north of Portugal (Tibell 1971; Sarrión *et al.,* 1999). Its world distribution area mainly ranges from the centre of Europe to the mediterranean mountains, and it is also known from North America (Tibell 1971).

Gyalecta ulmi (Swartz) Zahlbr. – Endangered
This epiphyte has been detected only in four populations, two in Serranía de Cuenca (Martínez *et al.,* 2002) and two in Calar del Mundo, growing on bark of very old *Juniperus thurifera, Quercus faginea* and *Q. ilex* subsp. *ballota* trees. It is usually associated with *Chaenotheca phaeocephala* and *Opegrapha varia*. It is a predominantly northern species in the Iberian Peninsula (Gómez-Bolea 1985; Etayo 1990a; López de Silanes *et al.* 1998; Jones 2000). Its world distribution is restricted to Europe (Purvis *et al.* 1992).

Hypocenomyce anthracophila (Nyl.) P. James & Gotth. Schneid. – Endangered
This is an epiphytic species which colonizes the fisures and cavities of tree bases in dense *Pinus nigra* forests in Sierra de Alcaraz (Aragón & Martínez 1999) and Serranía de Cuenca (Martínez *et al.,* 2002). It frequently occurs together with *Chaenotheca furfuracea, Cladonia fimbriata, C. ochrochlora* and *C. ramulosa*. In the Iberian Peninsula it is known only from one locality in the north (Etayo 1990a) and from the studied area. It is a circumboreal and montane species, known from Europe (Timdal 1984; Purvis *et al.,* 1992; Nimis 1993) and North America (Brodo *et al.* 2001).

Lecidea hypopta Ach. – Endangered
It has been found only on bark of *Pinus nigra* in one locality in Serranía de Cuenca (Martínez *et al.,* 2002) and one other in Sierra de Alcaraz (Aragón & Martínez 1999), comprising a very small number of thalli. It usually grows together with *Chaenotheca chrysocephala, Ch. ferruginea* and *Hypogymnia farinacea*. Although it is common in the centre and north of Europe, and North America (Purvis *et al.,* 1992), in Spain it is known only from Albacete and Cuenca provinces (Martínez *et al.,* 2002).

Letharia vulpina (L.) Hue – Endangered
This species grows in three forest stands, one in Sierra de Ayllón (Burgos & Burgaz 1990) and two in Serranía de Cuenca (Martínez *et al.,* 2002) on lignum of *Quercus pyrenaica* and on bark of *Pinus sylvestris*. Associated lichens are *Bryoria implexa, Hypogymnia farinacea, Parmelia saxatilis, Platismatia glauca* and *Pseudevernia furfuracea*. In the Iberian Peninsula it has a sparce distribution (Colmeiro 1889; Amo y Mora 1870; Lázaro Ibiza 1896; Gómez-Bolea 1985; Burgos & Burgaz 1990; Atienza *et al.,* 1992; Martínez & Aragón 1996; Martínez *et al.* 2001). Its world distribution area is Europe and western North America.

Megalaria laureri (Th. Fr.) Haf. – Critically Endangered
We have found a very small population in Montes de Toledo (Aragón & Martínez 1997), on bark of old *Ilex aquifolium*, under the canopy of *Quercus ilex* subsp. *ballota* trees. It occurs together with *Collema subnigrescens, Leptogium teretiusculum, Lobaria pulmonaria* and *Nephroma laevigatum*. It is known only from the north of Spain (Carballal & López de Silanes 1992; Etayo & Gómez-Bolea 1992). *M. laureri* is a subatlantic taxa which reaches the Mediterranean mountains (Wirth 1980; Nimis 1993). Its world distribution covers western Europe, from Portugal to coasts of Scandinavian Peninsula, Central Europe, Eastern Carpathian forests of western Ukraine, where it grows on *Carpinus* and *Corylus* by streams in sheltered valleys, and also North America (Purvis *et al.,* 1992).

Melaspilea urceolata (Fr.) Almb. – Critically Endangered
This extremely endangered lichen has a unique population in Calar del Mundo, growing on tree bases of isolated and old *Quercus faginea.* Other rare lichens of the same community are *Bacidia circumspecta, B. igniarii, B. incompta* and

Strangospora ochrophora. This species is known only from two localities in the north of Spain (Gómez-Bolea 1985; Etayo 1990a). In Europe it has a subatlantic distribution (Nimis 1993).

Microcalicium disseminatum (Ach.) Vain. – Critically Endangered (non-lichenized fungus)
This epiphyte has been detected only in one small population located in Serranía de Cuenca (Martínez *et al.,* 2002), where it colonizes very old trees of *Pinus nigra*. It grows together with *Chaenothecha chrysocephala, Ch. ferruginea* and *Chaenothecopsis debilis*. It is known only from two localities in the north of Spain (Etayo 1990a, 1992). However, it is widely distributed in the North Hemisphere, showing a Holarctic distribution (Tibell 1978; Purvis *et al.,* 1992; Nimis 1993).

Moelleropsis nebulosa (Hoffm.) Gyeln. – Endangered
Although it is usually a terricolous species, it has been found only on the base of *Quercus faginea* in two localities of Sierra Madrona. It has a sparse distribution in the Iberian Peninsula, being known only from some localities in the north (Sampaio & Crespí 1927; Tavares 1942; Gómez-Bolea 1985; Álvarez-Andrés *et al.* 1998), one in the east (Calatayud & Barreno 1994), and one more in the south (Seaward & Arvidsson 1997). The world distribution area of *M. nebulosa* is Europe (Purvis *et al.,* 1992; Nimis 1993) and North America (Jørgensen 2000).

Mycocalicium victoriae (C. Knight ex F. Wilson) Tibell – Endangered (non-lichenized fungus)
This species grows in two forest locations in Sierra Madrona (Sarrión *et al.,* 1993) on lignum of *Quercus pyrenaica*. It has a sparse world distribution, being also known from Mallorca (Boom 1999), Portugal (Boom & Giralt 1999), the Canary Islands (Hernández-Padrón *et al.* 1992), Australia and New Zealand (Tibell 1984).

Nephroma parile (Ach.) Ach. – Critically Endangered
We have found a very small population in a beech forest of Sierra de Ayllón (Burgos & Burgaz 1990). It grows on bark of *Fagus sylvatica* together with *Lobaria amplissima, L. pulmonaria, Nephroma resupinatum* and *Peltigera collina*. In the Iberian Peninsula it is more common in the north and the west, being rarer in other areas, where it appears only in humid sites (Burgaz & Martínez 1999), the Sierra de Gata in Cáceres province being its southern distribution limit (Martínez & Aragón 1998). It belongs to a Holarctic element, being disjunct in "Tierra de Fuego" in Chile (Nimis 1993).

Nephroma resupinatum (L.) Ach. – Endangered
It is known only from three localities, one in Sierra Madrona (Sarrión *et al.,* 1993), one in Sierra de Ayllón (Burgos & Burgaz 1990) and the other in Montes de Toledo (Martínez *et al.,* 1992). It grows on mossy tree bases of old *Fagus sylvatica* and *Quercus pyrenaica* trees, together with *Degelia plumbea, Lobaria pulmonaria, Peltigera collina* and *Pannaria mediterranea*. It is more abundant in the colline and montane belts of the eurosiberian fringe of the Iberian Peninsula, being restricted in the Mediterranean Region to some isolated forested sites (Burgaz & Martínez 1999). Sierra Madrona constitutes its southern distribution limit. Its world distribution area is Europe (Nimis 1993) and North America (Brodo *et al.* 2001).

Pannaria conoplea (Ach.) Bory – Critically Endangered
This epiphyte has been detected only in one small population located in a well-preserved Pyrenean oak forest stand in Sierra Madrona, growing on bark of *Arbutus unedo* together with *Catinaria atropurpurea, Degelia plumbea* and

Leptogium lichenoides. It is rather frequent in the north of Spain, although it is possible to find it southwards but restricted to more or less oceanic areas (Tavares 1950; Jones 1980; Carvalho 1997; Seaward & Arvidsson 1997; López de Silanes *et al.,* 1998; 1999; Boom & Giralt 1999). It belongs to the Holarctic element, being widespread and often common in Europe, North of Africa, the Canary Islands, Asia and North America (Jørgensen 1978, 2000; Nimis 1993; Etayo 1996).

Pannaria olivacea P.M. Jørg. – Endangered
It is known only from three localities, two in Montes de Toledo (Aragón & Martínez 1997) and the other in Sierra Madrona. The thalli colonize bark of *Juniperus oxycedrus*, growing under the canopy of *Quercus ilex* subsp. *ballota* trees. Other notable lichens are *Calicium montanum, Neofuscelia pulla* and *Xanthoparmelia conspersa*. Its distribution in the Iberian Peninsula is restricted to the southern half, Montes de Toledo being its northern distribution limit (Arvidsson 1979; Aragón & Rico 1997; Seaward & Arvidsson 1997; Fos 1998). It is a Mediterranean species whose distribution ranges from Turkey to the south of Portugal (Jørgensen 1978; Jones 1980; Codogno & Puntillo 1993; Puntillo 1993; Christensen 1994; John 1996), including northern Morocco (Arvidsson 1979), Mallorca (Boom 1999) and Madeira (Jørgensen 1978).

Pannaria pezizoides (Weber) Trev. – Endangered
It is a very rare species, found on tree bases of *Quercus pyrenaica* in Sierra de San Vicente (Vázquez & Burgaz 1996) and Sierra de Ayllón. It is known only from some northern localities in the Iberian Peninsula (Llenas 1910; Tavares 1965; Etayo 1990a; Carballal *et al.,* 1995; Martínez *et al.* 1995; Martínez & Aragón 1996; López de Silanes *et al.,* 1998; Aragón *et al.* 1999), Sierra de San Vicente being its southern distribution limit. Its world distribution area is Europe, North Africa and North America (Brodo *et al.* 2001; Nimis 1993), with an outlier in the high mountains of East Africa (Jørgensen 2000).

Peltigera horizontalis (Huds.) Baumg. – Endangered
It is known only from six localities, four in Montes de Toledo (Martínez 1999), one in Sierra Madrona and the other in Sierra de Ayllón (Martínez 1999). It grows on mossy tree bases of old phorophytes such as *Fagus sylvatica, Quercus ilex* subsp. *ballota* and *Q. pyrenaica* and, represented by a very small number of thalli. It usually appears together with *Dendriscocaulon umhausense, Lobaria pulmonaria, Pannaria ignobilis* and *Peltigera collina.* It is rather frequent in the north of the Iberian Peninsula, Sierra de Cazorla being its southern distribution limit. In the Iberian Mediterranean Region it is scarce and confined to the mountains and oceanic areas (Martínez 1999). It has a holarctic distribution (Vitikainen 1994).

Peltigera venosa (L.) Hoffm. – Endangered
It is confined to siliceous soils inside forests of *Fagus sylvatica* or *Erica australis* shrubs in one locality of Sierra de Ayllón (Martínez 1999). It is scarce in the Iberian Peninsula, restricted to the northern half, this locality being its southern distribution limit. It belongs to the Holarctic element, and is known from Europe, Asia and North America (Vitikainen 1994).

Protoparmelia oleagina (Harm.) Coppins – Critically Endangered
This extremely endangered lichen has a unique population in Sierra Madrona comprising a very small number of individuals. This location is an old-growth forest of *Pinus pinaster*. In the Iberian Peninsula it is known only from this locality and from Navarra province in the north of Spain (Etayo 1990a). It is also known from the

British Isles, South of France, Spain, Sweden, Netherlands and Germany (Aptroot *et al.*, 1997).

Psoroma hypnorum (Vahl) Gray – Critically Endangered
It is a terricolous species which grows on mosses in only one locality of the Sierra de Ayllón (Burgos & Burgaz 1990). It is rather rare in the Iberian Peninsula, being more abundant in the Eurosiberian Region and the Sierra de Ayllón is its southern distribution limit in Europe (Martínez & Aragón 1996). Its world distribution area is Europe (Jørgensen 1978), North America (Brodo *et al.* 2001), Australia (Filson 1996) and Chile (Galloway & Quilhot 1998).

Rinodina dalmatica (Croz.) Zahlbr. – Endangered
It grows only in two well-preserved forest stands in Sierra Madrona (Fos *et al.* 2000) on lignum of *Quercus pyrenaica* and *Q. suber* trees. It usually appears together with *Calicium abietinum* and *Pertusaria albescens*. In the Iberian Peninsula it is known only from Badajoz, Cádiz, Ciudad Real and Jaén provinces in Spain (Fos *et al.,* 2000), and from Portugal (Giralt *et al.* 1995; Boom & Giralt 1999). Although there are not many references, its distribution pattern seems to be Atlantic-Mediterranean (Giralt *et al.,* 1995). Its world distribution area is limited to Croatia, France, Greece, Italy, Portugal and Spain (Bouly de Lesdain 1909; Harmand 1913; Magnusson 1947; Giral *et al.* 1994, 1995; Boom & Giralt 1996; Boom 1999).

Rinodina griseosoralifera Coppins – Critically Endangered
It has been found on mossy tree bases of Pyrenean oak (*Quercus pyrenaica*) in only one locality, in Sierra de San Vicente (Vázquez & Burgaz, 1996), comprising a very low number of individuals. In the Iberian Peninsula it is known only from a few localities in the southern half of Spain (Diederich *et al.* 1991; Vázquez & Burgaz 1996; Fos 1998; Martínez & Aragón 1998). In Europe it is known from the British Isles, Austria Belgium, Luxembourg and Norway (Coppins 1989; Purvis *et al.,* 1992; Diederich & Sérusiaux 2000), and Spain, and Tønsberg (1993) has reported it from USA (Oregón).

Solorina bispora Nyl. – Critically Endangered
It is a very scarce species, growing on calcareous soils and is known only from one locality in the supramediterranean belt of Sierra de Alcaraz (Burgaz & Martínez 1998). It grows together with *Peltigera rufescens, Psora decipiens* and *Toninia sedifolia*. In the Iberian Peninsula it usually grows in the Cantabric mountains and the Pyrenees, but reaches the Sierra de Alcaraz in southern Spain (Burgaz & Martínez 1998). Its world distribution area is Europe (Purvis *et al.* 1992) and the southern Rock Mountains of USA (Brodo *et al.* 2001).

Strangospora microhaema (Norman) R.A. Anderson – Endangered
This lichen has been detected only in two small populations, in Sierra Madrona, growing on tree bases of very old *Quercus faginea* and *Q. pyrenaica* trees. Other rare lichens of the same community are *Bacidia circumspecta, B. igniarii* and *Strangospora ochrophora*. Outside our territory, it is known only from few localities in the northern half of the Iberian Peninsula (Crespo *et al.,* 1980; Marcos 1986; Boom *et al.,* 1990; Boom & Gómez-Bolea 1991; López de Silanes & Carballal 1991; López de Silanes *et al.,* 1998). It belongs to the Holarctic element, known from old-growth forest stands in the north, centre and southeast of Europe, but it has been recently collected from Madeira and North America (Kalb & Hafellner 1992; Purvis *et al.,* 1992; Nimis 1993).

VALUABLE HABITATS FOR LICHEN CONSERVATION AND PROPOSED AREAS FOR PROTECTION

The habitat preferences of all threatened lichens and the numbers of species associated with each habitat type are given in Table 2.

We note that deciduous woodlands are where the majority of threatened species occur, followed by sclerophyllous and pine forests. Additionally, we also observe that juniper forests are relevant for the existence of many endangered species, especially lignicolous lichens. On the other hand, some widely distributed habitats such as rockrose shrubs (*Cistus*), bare calcareous and acid soils support a very small list of threatened species, probably as a consequence of the enormeous extension of these habitat types in the territory. However, it must be noted that soil and rock habitats have been comparatively little explored, so their conservation value may be currenly under-estimated.

The most valuable habitats and localities are described. Furthermore we propose some conservation areas (hotspots), which comprise the higher number of threatened lichens (Table 3, Fig. 1). As the localities are small in extent (< 5 km^2) most of them may be actively managed as microreserves (see details in Akeroyd, 1998).

Deciduous woodlands

Quercus faginea, Q. pyrenaica and *Fagus sylvatica* forests are the most important landscape elements for threatened lichens in our region because they accommodate 43 species.

These deciduous forests, whose optimal distribution is actually Eurosiberian, appear confined to the montane zones, where the climatic conditions are suitable for their existence. Traditionally, they have been exploited in different ways: wood extraction, wood for heating, grazing by cattle, meadow management for winter fodder and even conversion to conifer plantation.

We propose two well-preserved *Quercus pyrenaica* forest stands in Sierra Madrona for protection: 'Robledo de las Hoyas' and 'Umbría de la Sierra de Dornilleros-La Cereceda'. In these locations *Quercus pyrenaica* is almost the only species that forms the canopy but other trees can sporadically occur, such as *Acer monspessulanum*, *Arbutus unedo*, *Prunus avium, Sorbus aria, S. domestica,* and *S. torminalis*. The stands are well age-structured and there is no evidence of recent human disturbance. They sustain a high lichen diversity, especially communities of large foliose cyanolichens associated with bryophytes, and support many threatened species, such as *Calicium montanum, Catinaria atropurpurea, C. montana, Cetraria merillii, Degelia atlantica, Koerberia biformis, Lobaria amplissima, L. pulmonaria, L. scrobiculata, Mycocalicium victoriae, Nephroma resupinatum, Peltigera horizontalis, Rinodina dalmatica, Strangospora microhaema, Waynea adscendens,* etc.

We also propose one *Quercus faginea* subsp. *broteroi* forest stand also located in Sierra Madrona: 'Arroyo del Puerto'. It is home to 9 threatened lichens and non-lichenized fungi: *Catinaria montana, Degelia atlantica, Koerberia biformis, Lobaria amplissima, L. pulmonaria, Mycocalicium victoriae, Pannaria conoplea, Strangospora microhaema* and *Waynea adscendens.* This type of well-developed forest is really scarce in the territory and usually confined to the most humid soils.

We suggest only one *Quercus pyrenaica* forest stand in Montes de Toledo for active conservation: 'Arroyo de la Hiedra'. This forest in the supramediterra-

Table 2. Habitat types and threatened species in each habitat classified following their conservation status.

Deciduous woodlands	Sclerophyllous forests	Coniferous forests	Juniper forests	Cistus shrubs	Limestones soils	Acid soils
CR	**CR**	**CR**	**CR**		**CR**	**CR**
Acrocordia cavata	*Megalaria laureri*	*Cyphelium inquinans*	*Aspicilia lignicola*		*Solorina bispora*	*Psoroma hypnorum*
Catinaria montana		*C. notarisii*	*Bacidia absistens*			
Melaspilea urceolata		*Microcalicium disseminatum*	*Biatora ocelliformis*			
Nephroma parile		*Protoparmelia oleagina*				
Pannaria conoplea						
Rinodina griseosoralifera						
EN	**EN**	**EN**	**EN**			**EN**
Agonimia allobata	*Agonimia allobata*	*Cetraria sepincola*	*Bacidia incompta*			*Peltigera venosa*
Calicium montanum	*Calicium montanum*	*Chaenotheca phaeocephala*	*Chaenotheca*			
Catinaria atropurpurea	*Catinaria atropurpurea*	*Ch. trichialis*	*phaeocephala*			
Chaenotheca phaeocephala	*Chaenothecopsis pusilla*	*Ch. xyloxena*	*Ch. trichialis*			
Gyalecta ulmi	*Pannaria olivacea*	*Cladonia cenotea*	*Gyalecta ulmi*			
Letharia vulpina	*Peltigera horizontalis*	*Hypocenomyce anthracophila*				
Moelleropsis nebulosa		*Lecidea hypopta*				
Mycocalicium victoriae		*Letharia vulpina*				
Nephroma resupinatum						
Pannaria pezizoides						
Peltigera horizontalis						
Rinodina dalmatica						
Strangospora microhaema						
VU	**VU**	**VU**	**VU**	**VU**	**VU**	**VU**
Agonimia octospora		*Bryoria capillaris*	*Buellia cedricola*	*Cetraria crespoae*	*Cetraria steppae*	*Cladina arbuscula*
Bryoria capillaris	*Agonimia octospora*	*B. implexa*	*Pertusaria paramerae*	*C. merillii*	*Cladonia subrangiformis*	*Cladonia cryptochlorophaea*
Calicium lichenoides	*Buellia cedricola*	*Calicium lichenoides*	*Waynea adscendens*	*Cladonia iberica*	*Peltigera monticola*	*C. iberica*
Cetraria crespoae	*Cladonia incrassata*	*Cetraria crespoae*	*Xylographa abietina*		*Sphaerothallia fruticulosa*	*Leptochidium albociliatum*
Cladonia furcata	*Collema fasciculare*	*Chaenotheca furfuracea*			*S. hispida*	
C. squamosa	*C. flaccidum*	*Cyphelium tigillare*			*Xanthoparmelia vagans*	
C. symphycarpa	*C. nigrescens*	*Pannaria rubiginosa*				
Collema nigrescens	*C. subflaccidum*	*Parmeliopsis hyperopta*				
C. subflaccidum	*C. subnigrescens*	*Pertusaria ophthalmiza*				
C. subnigrescens	*Cyphelium tigillare*	*P. paramerae*				
Cyphelium tigillare	*Degelia atlantica*	*Vulpicida pinastri*				
Degelia atlantica	*D. plumbea*	*Xylographa abietina*				
D. plumbea	*Koerberia biformis*					
Koerberia biformis	*Leptogium saturninum*					
Leptogium saturninum	*Lobaria pulmonaria*					
Lobaria amplissima	*Mycobilimbia berengeriana*					
L. pulmonaria	*Pannaria ignobilis*					
L. scrobiculata	*P. rubiginosa*					
Pannaria ignobilis	*Parmelia submontana*					
Parmelia submontana	*Parmotrema chinense*					
Parmotrema chinense	*Waynea adscendens*					
Usnea fulvoreagens						
Waynea adscendens						
43	28	25	11	3	5	6

Table 3. Proposed areas for conservation, indicating the predominant habitat type, UTM squares (10 × 10 km), province, minimum extension area of the proposed area (km^2) and number of threatened species in each locality with the percentage (%) between parenthesis.

	Conservation areas	UTM	province	surface	Total number threatened species	number of threatened species		
						CR	EN	VU
Deciduous woodlands	'Robledo de las Hoyas **(A)**	30SUH85	CR	1.4	18	2 (12.5)	5 (19.5)	11 (23.9)
	'Umbría de la Sierra de Dornilleros-La Cereceda' **(B)**	30SUH95	CR	4.2	22	2 (12.5)	9 (33.3)	11 (23.9)
	'Arroyo del Puerto' **(C)**	30SUH86	CR	0.6	10	0	1 (3.7)	9 (19.5)
	'Arroyo de la Yedra' **(D)**	30SUJ87	TO	4.1	18	0	3 (11)	15 (32.5)
	'Tejera Negra' **(E)**	30TVL66	GU	1.8	17	1 (6.25)	4 (14.8)	12 (26)
Sclerophyllous forests	'Río Mundo' **(F)**	30SWH45	AB	0.7	21	4 (25)	0	17 (37)
	'Río Valmayor' **(G)**	30SUH95	CR	3.2	8	1 (6.25)	1 (3.7)	6 (13)
	'Río Estena' **(H)**	30SUJ68	TO	2.8	25	3 (18.75)	2 (7.4)	20 (43.5)
	'Arroyo del Chorro' **(I)**	30SUJ57	TO	3.2	23	2 (12.5)	1 (3.7)	20 (43.5)
Pine forests	'Calar de la Osera' **(J)**	30SWH56	AB	1.7	13	4 (25)	3 (11)	6 (13)
	'Dehesa de los Palancares' **(K)**	30TWK93	CU	4.6	10	2 (12.5)	3 (11)	5 (10.8)
Juniper forests	'Majada de la Ceja' **(L)**	30TWK94	CU	1.8	13	2 (12.5)	2 (7.4)	9 (19.5)
	'Cotillas' **(M)**	30TWK83	CU	2.5	15	2 (12.5)	4 (14.8)	9 (19.5)

nean belt is rich in tree species, such as *Ilex aquifolium*, *Sorbus aria*, *Fraxinus angustifolia*, and supports a valuable list of threatened species, such as *Collema nigrescens, Degelia atlantica, Leptogium saturninum, Lobaria amplissima, L. pulmonaria, L. scrobiculata, Pannaria ignobilis,* etc.

Finally, we propose for protection the best-preserved beech forest in the territory: 'Tejera Negra'. This forest is one of the southermost localities for the species. Unfortunately, the stand has suffered major transformations as a consequence of past forestry activities. In any case the remnant fraction has now been included in a Natural Reserve (Natural Park of Tejera Negra). The canopy layer is dominated by *Fagus sylvatica*, but sporadically other trees such as *Quercus petraea*, *Taxus baccata* and *Populus tremula* appear. In this location we can find 17 threatened species, almost all of them belonging to the *Lobarion* communities: *Degelia plumbea, Lobaria amplissima, L. pulmonaria, L. scrobiculata, Nephroma parile, Pannaria pezizoides, Peltigera horizontalis,* etc.

Sclerophyllous forests

Sclerophyllous forests, especially *Quercus ilex* subsp. *ballota* forests, are the most representative and conspicuous landscape element in the Iberian Peninsula and also in Central Spain. Fortunately, large stands still remain wellpreserved, both as coppice stands and also as 'dehesas', which is an antropogenic open pasture woodland formation of wide extent in the western half of the territory. Some of the best-conserved *Quercus ilex* subsp. *ballota* stands contain some of the most endangered Mediterranean lichens of the territory, totalling 28 species.

One of the most relevant localities in conservation terms is Calar del Mundo (Albacete). This old-growth stand presents a tree canopy layer almost exclusively composed of *Quercus ilex* subsp. *ballota*, but enriched under more humid conditions with other trees, such as *Acer monspessulanum*, *Corylus avellana*, *Crataegus monogyna*, *Fraxinus angustifolia*, *Quercus faginea*, and *Ulmus glabra*. This forest is located in a steep ravine crossed by the river Mundo. This special situation allows the existence of a great lichen diversity and many threatened lichens, such as *Bacidia incompta, Degelia atlantica, D. plumbea, Gyalecta ulmi, Koerberia biformis, Lobaria pulmonaria, L. scrobiculata, Pannaria rubiginosa, Waynea adscendens*.

In Montes de Toledo there are various very interesting *Quercus ilex* subsp. *ballota* stands located in isolated and inaccessible valleys. Probably the most valuable in relation to lichen diversity are 'Río Estena' and 'Arroyo del Chorro'. The forests are composed by very old trees of *Arbutus unedo, Fraxinus angustifolia, Ilex aquifolium, Juniperus oxycedrus,* and locally some eurosiberian trees such as *Quercus pyrenaica, Sorbus torminalis* and *Taxus baccata.* Threatened lichens in such forests include: *Buellia cedricola, Calicium montanum, Catinaria atropurpurea, Chaenothecopsis pusilla, Degelia atlantica, Koerberia biformis, Lobaria amplissima, L. pulmonaria, L. scrobiculata,* and *Megalaria laureri.*

Finally, we highlight the locality 'Río Valmayor' in Sierra Madrona (Ciudad Real), which comprise a 'dehesa' formation with large and old *Quercus ilex* subsp. *ballota* trees. This forest supports such threatened species as *Agonimia allobata, Collema nigrescens, C. subflaccidum, Koerberia biformis, Lobaria amplissima* and *L. scrobiculata*, which clearly suggests the value of some anthropogenic landscape units for the conservation of endangered elements.

Pine forests

Although pine forests are extensive in Central Spain and are dominated by contrasting species, outstanding localities for lichen conservation belong to supramediterranean and subhumid *Pinus nigra* stands. The remarkable localities at Serranía de Cuenca and Sierra de Alcaraz accommodate 25 threatened species.

We propose for conservation the locality 'Calar de la Osera' in Sierra de Alcaraz. This is a very well-preserved forest with a great density (80%) located in a steep valley. The tree canopy layer is dominated by *Pinus nigra,* although locally some *Acer granatense* and *Ilex aquifolium* appear. Some of the most endangered species we can find here are *Chaenotheca phaeocephala, Ch. trichialis, Cyphelium inquinans, Hypocenomyce anthracophila, Lecidea hypopta, Peltigera monticola, Pertusaria paramerae*, etc.

Furthermore, we suggest the necessity for conservation of 'Dehesa de los Palancares' in Serranía de Cuenca, especially some of the less disturbed dolines where forest are well-structured. Dolines determine the existence of contrasting microclimate conditions in a very reduced space which allow the existence of a great lichen diversity: *Bryoria implexa, Calicium lichenoides, Chenotheca chrysocephala, Ch. ferruginea, Chaenotheca furfuracea, Ch. phaeocephala, Ch. xyloxena, Hypocenomyce anthracophila, Lecidea hypopta, Microcalicium disseminatum,* etc.

Juniper forests

One special habitat is the *Juniperus thurifera* formations, especially those well-preserved in Serranía de Cuenca. These open woodlands almost exclusively dominated by *Juniperus thurifera,* a tertiary relict tree, constitute a typical element in the continental centre of Spain, and are confined to hard limestones of the supramediterranean belt.

We propose for protection two localities in Serranía de Cuenca: 'Majada de la Ceja' and 'Cotillas'. Within these forests two different groups of threatened species occur. The first group colonizes bark and extremely hard lignum of very old trees: *Aspicilia lignicola, Biatora ocelliformis, Buellia cedricola, Chaenothecopis debilis,* etc. The second group is characterized by species that grow on shaded and mossy areas of old and large trees, protected by the canopy of the

junipers. In this situation a special microclimate is created and favours the existence of species with high humid requirements such as *Bacidia incompta, Chaenotheca phaeocephala, Ch. trichialis, Gyalecta ulmi, Waynea adscendens,*etc.

Acknowledgements. This study was supported by the Spanish Project DGES, PB96-1115-C04-04 and by the Spanish 'Junta de Comunidades de Castilla-La Mancha, Consejería de Agricultura y Medio Ambiente, Dirección General del Medio Natural', projects TO/14/96, AB/17/96, CR/01/97, CU/03/97, CM/02/97, AB/10/98, CU/07/98, CM/01/99, CM/01/00, CM/01/01.

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