FLORA AND VEGETATION

FLORA

VASCULAR PLANTS

[Giovanna Abbate, Alessandro Alessandrini, Fabio Conti]

The terms vascular plants, or tracheophytes, refer to all those plant organisms which have true conductive tissue. Vascular plants comprise the biggest of the groups of green plants and form the dominant vegetation over the greater part of the land surface of planet earth. Belonging to this huge group are the Lycopods, the Equiseta, the Ferns and the Spermatophytes or Phanerogams, that is, seed-bearing plants. These latter, in turn, are comprised of the Cycads, Ginkgo, the Conifers, the *Gnetales* and the large group of Angiosperms, better known as flowering plants. Traditionally the Angiosperms were divided into Dicotyledons and Monocotyledons; recently, however, systematic studies have led to a further division of Dicotyledons into more archaic groups (Paleoherbs and *Magnoliidae*) and Eudicotyledons.

Floristic research in Italy

By vascular flora is meant all vascular units occurring in a given area. Relatively few general works have been published on Italian vascular flora; however, mention should be made of BERTOLONI (1833-54), PARLATORE (1848-1896), FIORI (1923-1929), ZANGHERI (1976) and, more recently, PIGNATTI (1982). Each of these works is valuable in its own right, in that it provides a record of the state of knowledge at the historical period in which it was produced. In fact, comparison between floras of different periods reveals changes in the number of species dealt with. These changes are the result of: improved knowledge of systematics; more thorough exploration of the national territory; the description of new species, often endemics; the reassessment of a number of units; and, finally, the arrival of adventitious plants. Therefore each overall Flora, besides its actual value, has also a specific value related to the historical context as well as to the previous and following Floras.

After a period during which they had virtually come to a standstill, floristic studies at regional and local level have, over the last twenty years, undergone a revival (AA.VV., 1978-2001; POLDINI, 1991; LUCCHESE, 1995; ANZALONE, 1996; ALESSANDRINI e BRANCHETTI, 1997). Also, over this same period, developments in computer technologies, in parallel with a growing need for information about, and conservation of, the environment, have encouraged the planning and construction of numerous databases of flora (which have however, differed widely in terms of content and size)**.** We note, for example, the databases of flora set up by the Valle d'Aosta Region (BOVIO *et al.*, 2000) and Friuli-Venezia Giulia Region (POLDINI *et al.*, 2001).

The database of the Italian vascular flora[1]

This database is significant in being the first computerised instrument for analysing Italy's floristic diversity. It is not intended to be a critical revision of a taxonomic kind. Rather, it is an important collection of the entity of floristic information that has been acquired over the last twenty years.

The primary objective of the project was to bring together all the floristic information available for Italy in a

[1] It was built in the period 1999-2002 by the Department of Plant Biology at the University of Rome 'La Sapienza', financed by the Ministry for the Environment Land and Sea Protection and the Protection of the Territory, Nature Conservation Direction.

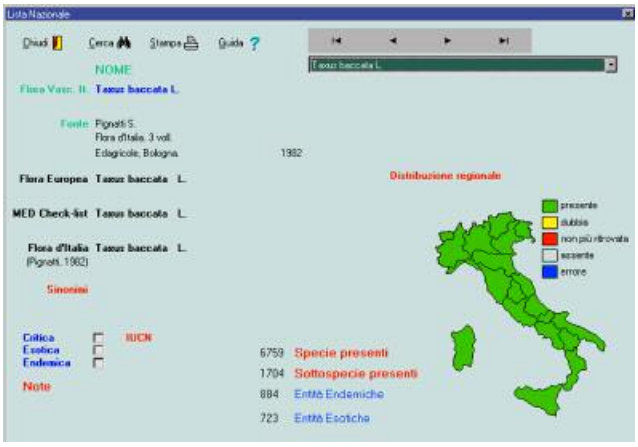

Fig. 4.1 - Interrogation form of the Database for the national list.

Fig. 4.2 - *Taxus baccata* L., a Gymnosperm widespread in Italy, as can be seen on the screen of the Database in Figure 4.1 (Photo by E. Giovi).

systematic and consistent way, making it accessible to a wide range of users. Numerous botanists from the various Regions of Italy participated in the project and they provided much data which was in the process of being published, thus ensuring that the details included in the database were almost completely up-to-date.

The data used in drawing up the list of vascular species occurring in Italy were taken from the three main sources currently available: *Flora d'Italia* (PIGNATTI, 1982), *Med-Checklist* (GREUTER *et al.,* 1984, 1986, 1989) and *Flora Europaea* (TUTIN *et al.*, 1968-1980, 1993). Subsequently some reports found in floristic literature were added along with reports from experts on regional flora and on particular *taxa*.

Monographs recently published and the Flora of other European countries were used to update the nomenclature.

The following database fields were set up: taxonomical and/or nomenclatural critical status; Distribution; Endemic status; Aliens; IUCN Categories; Regional Protection; International status.

To query the database a special program was written which provides for dual access: 1) to the data of the national list; 2) to the data of the individual lists compiled for each of the 20 Italian administrative regions. Either options allow for the bulk of the information contained in the data-base to be accessed. By way of illustration, Figure 4.1 show the screen display for the record of the species *Taxus baccata* L. (Figure 4.2).

For a more detailed description of the structure and contents of the database the reader is referred to ABBATE *et al.* (2001). The data discussed in this chapter are taken from the database and are limited to either spontaneous *taxa*, or naturalised adventitious *taxa* whose life-cycle has been completed entirely in nature for several years.

The numbers of Italian vascular flora

Italian vascular flora, according to the recently completed database[2], consists of a total of 6,711 species divided into 196 families and 1,267 genera. Tab. 4.1 gives the numbers for the four principal systematic categories: *Pteridophyta*, *Gymnospermae*, *Angiospermae Dicotyledones* and *Angiospermae Monocotyledones*. The families with the greatest number of members are, predictably, those belonging to the angiosperms and are, in decreasing order: *Compositae* (1,028 species), *Leguminosae* (445), *Rosaceae* (334), *Cruciferae* (297) and *Caryophyllaceae* (289) within the Dicots; *Graminaceae* (535), *Cyperaceae* (193) and *Orchidaceae* (124) in the Monocots (Tab. 4.2).

The numbers calculated for the regional level show that many of the regions of Italy possess a substantial floristic patrimony - in particular, those regions in which a wide diversity of environmental types is to be found: Piemonte (3,521 species), Toscana (3,435), Friuli-Venezia Giulia

	Number of species
PTERIDOPHYTAE	124
GYMNOSPERMAE	28
ANGIOSPERMAE DICOTYLEDONES	5,230
ANGIOSPERMAE MONOCOTYLEDONES	1,329
Total	**6,711**

Table 4.1 - Number of species of the Italian vascular flora, divided in the four main taxonomic categories.

[2] The data contained in the database have been continuously updated at the Department of Plant Biology of the University of Rome 'La Sapienza', even after the conclusion of the convention with the Ministry for the Environment Land and Sea Protection and the Protection of the Territory, up to February 2005.

	nº specie
ANGIOSPERME DICOTILEDONI	
Compositae	1.028
Leguminosae	445
Rosaceae	334
Cruciferae	297
Caryophyllaceae	289
Umbelliferae	238
Scrophulariaceae	220
Labiatae	203
Ranunculaceae	165
Plumbaginaceae	131
ANGIOSPERME MONOCOTILEDONI	
Graminaceae	535
Cyperaceae	193
Orchidaceae	124

Tabella 4.2 - Famiglie più rappresentate nella flora vascolare italiana e loro consistenza in specie.

(3,335), Veneto (3,295), Abruzzo (3,232), Lazio (3,228) and Lombardia Region (3,435) (Figure 4.3).

If these numbers from the database are compared to those reported by PIGNATTI (1982; 1994), a marked increase is apparent in the numbers of families, genera and species at both a national and a regional level. Nationally the number of species has risen by 1,112, the number of genera by 21 and the number of families by 16. In part, these increases are due either to the discovery of *taxa* that are new to science, or to the discovery within the borders of Italy of plants already known for adjacent countries. However the increases are also attributable to two further factors: 1) the entry and naturalisation of ever greater numbers of alien species, arriving from distant lands as a result of human activity; and 2) the carrying out of in-depth taxonomic studies on different groups, which led to new interpretations of the variability and different attributions of variability at a species level.

Currently the number of naturalised alien species surveyed for Italy stands at 751 -comprising 11.2% of the total flora - of which a large portion are of American origin (GENTILE, 1991). If we consider that in 1974 VIEGI *et al.* put the number of alien species which had entered to form a permanent part of the Italian flora at 527, it can be confirmed that over recent decades a 'floristic pollution' has begun, in Italy, to assume dimensions which cannot be ignored.

In their recent historical analysis, ALESSANDRINI & PALAZZINI CERQUETELLA (2001) show that, from the beginning of the nineteenth century onwards, there has been a clear tendency towards an increase in the total number of genera dealt with in the principal works on Italian flora. The main reasons for this increase are: the institution of new genera, the recovery of genera which had been neglected, and the discovery of genera which were new for the Italian flora. Figure 4.4 shows the numbers of genera, updated using the data available to us.

In the future the numbers for the different hierarchical ranks will be liable to further variation as new data are acquired, especially for those Regions which have, as yet, been poorly studied, such as Basilicata and part of Campania. It will then be essential to carry out in-depth studies on those groups which are taxonomically critical, characterised by a complex reproductive biology; we note, for example, a few genera within the families *Rosaceae* (*Rosa*, *Rubus*, *Alchemilla*) and *Compositae* (*Centaurea*, *Hieracium*), upon which some studies are already under way. Moreover, not to be underestimated are the many knotty problems of a nomenclatural nature which still need resolving – this, in its turn, is likely to have repercussions of a quantitative nature.

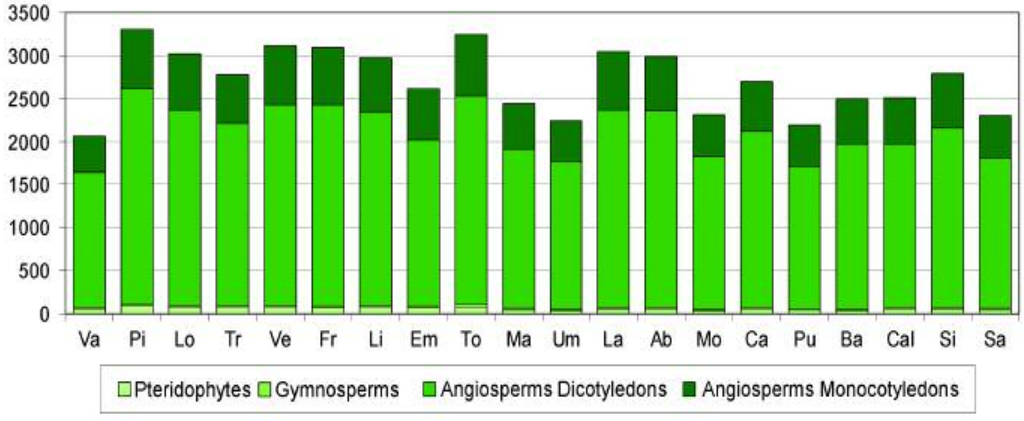

Fig. 4.3 - Number of species belonging to Pteridophytes, Gymnosperms, Angiosperms Dicotyledons and Angiosperms Monocotyledons, in the 20 Italian regions (abbreviations of the regions like in CONTI *et al.*, 1997).

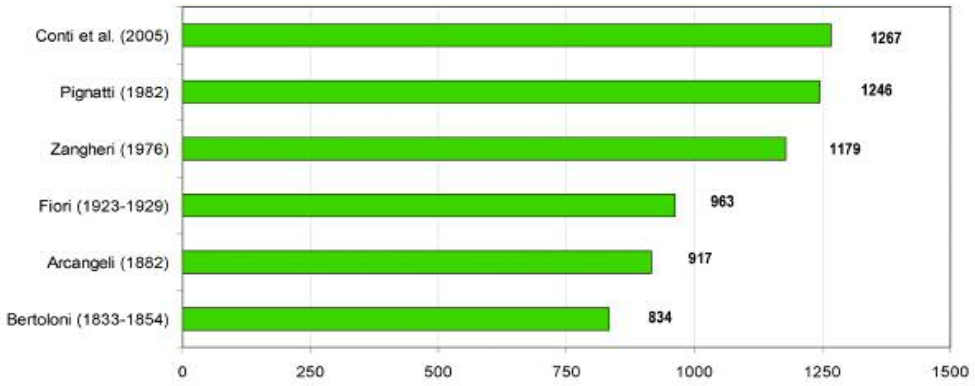

Fig. 4.4 - Number of genera in the main works on the Italian flora (Alessandrini & Palazzini Cerquetella, 2001, updated).

The endemic units

In phytogeographical terms, Italian vascular flora can be divided into nine main chorotypes - where chorotype refers to a group of species whose distribution area coincides (Pignatti, 1982. Table 4.3).

On the basis of assessments made by Anzaldi *et al.* (1988), alongside the large groups of Eurasiatics (20.93%) and Stenomediterraneans (16.65%), is the group of Endemics, which taken together comprise 13.5% - a proportion which is just slightly lower.

Although the number of endemics surveyed for Italy is well below that attained in island countries, it is nevertheless still quite high and in the main it is the Alpine, Apennine and Sardinian-Corsican endemics which are responsible for this.

This chapter gives updated data for Italy (at a national and a regional level) for a category which includes only Endemics in the strict sense, plus Sardinian-Corsican Endemics (Figure 4.5). Subendemic *taxa* were not taken into account here and consequently the numbers of Endemics reported above cannot be compared with those reported in Anzaldi *et al.* (*l.c.*), which are inclusive of Subendemic *taxa*.

From the analysis of our data it emerges that the total number of endemics, including *taxa* of a subspecific rank, is no less than 1,021 - of which 767 are species and 281 subspecies. At a regional level the islands Sicilia and Sardeg-

Endemic: species occurring only in one territory (geographic area, region, country) or in a part of it. They are divided into *Paleoendemics* and *Neoendemics*, which originated respectively during pleistocene and postglacial.
Mediterranean: species with a distribution area centred in the Mediterranean Basin. They are divided into *Stenomediterraneans*, occurring along the coasts and in the warmer areas, *Eurimediterraneans*, extending to the Central Europe, and *Mediterranean-mountains*, occurring in the mediterranean mountain ranges.
Eurasiatic: species spread in the Eurasian continent. They include species *south-European/south-Siberian*, typical of the warm regions of Europe; *Pontic*, occurring in south-eastern continental Europe (N of Black Sea-Balkans), *Illyrian/Amphiadriatic*: spread in the Balkans and along the Adriatic side of the Italian peninsula; *Paleotemperate*, typical of the paleoarctic temperate zones (Eurasia and N-Africa), *Eurasiatic*, occurring from Europe to Japan, and *Turanian*, with distribution areas centred in Middle East, Turkey, internal steppic and desertic Asia (sometimes also Caucasus, Balkans and Mediterranean).
Atlantic: they are the western components of our flora, centered in the Atlantic coasts. They are divided into A*tlantic (Amphiatlantic)*, typical of the western temperate-oceanic sectors of Europe and *Mediterranean-atlantic*, occurring in the Atlantic and Mediterranean coastal zones.
S-European Orophyle: mountain and alpine species of the reliefs of southern Europe (Pyrenees, Alps, Carpathians, Dinaric Alps).
Boreal: species restricted to the colder parts of Europe and North-America (in Italy mostly on the Alps). They are divided into *Arctic-alpine*, typical of the circumarctic and alpine high zones, *circumboreal*, spread in the holarctic temperate-cold zones (Eurasia and North-America), and *Euro-Siberian*, restricted to the paleoarctic temperate-cold zones (Eurasia).
Widely distributed groups: species occurring everywhere or nearly everywhere in the world. They include the *Cosmopolitan* species, occurring in all biogeographic regions, *Subcosmopolitan*, widespread but with large interruptions (*e.g.* continents or whole bioclimatic zones), *Paleotropical*, spread in the tropical countries of Africa and Asia, *pantropical*, occurring in the tropical belt of Eurasia, Africa and America, and finally *adventitious* and *naturalized alien*, transitory or permanent populations of species native of different biogeographic regions.

Table 4.3 - Summary of the main chorological types of the Italian vascular flora (from Pignatti, 1982).

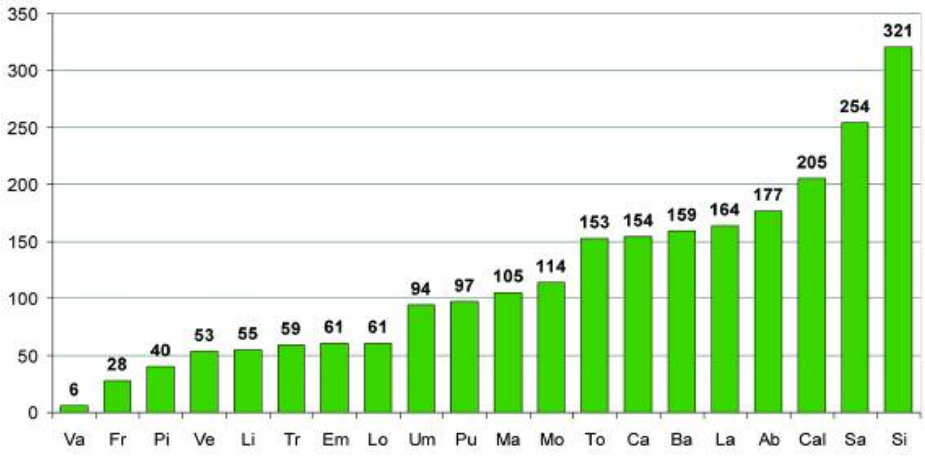

Fig. 4.5 - Number of endemic units (species and subspecies) in the 20 Italian regions (abbreviations of the regions like in CONTI *et al.*, 1997).

Fig. 4.6 - *Viola aethnensis* Parl. subsp. *messanensis* (W. Becker) Merxm. et Lippert, endemic unit of the southern Apennine and Sicilia (Photo by S. Bonacquisti).

na display, as might be expected, numbers which are very high - 321 and 254, respectively. Following this come Calabria (205), Abruzzo (177), Lazio (164) and Basilicata Region (159). The Regions of the Alpine chain tend to host *taxa* which are more Subendemic and thus in general display lower numbers.

Taxonomical diversity and floristic diversity

Some first quantitative assessments of the state of conservation of the regional flora can be made using some Indices of taxonomical diversity which have been widely tested (POLDINI, 1991; SELVI, 1998). The Indices here considered are based on the ratios between the number of families and the number of genera, and between the number of genera and the number of species. These ratios are considered good indices of diversity because they are sensitive to the presence of *taxa* which are not closely related and which are therefore different with respect to their ecological traits.

Analysis of the data given in Table 4.4 indicates that the Regions with the highest taxonomical diversity are Puglia, Umbria, Sardegna, Molise, Marche and Emilia-Romagna. If we instead analyse only the absolute numbers of units (Table 4.5), the richest Regions are Piemonte, Toscana, Friuli-Venezia Giulia, Veneto and Abruzzo. In order to better evaluate the floristic richness, the number

	n. of families	n. of genera	n. of species	n. of families/ n. of genera (%)	n. of genera/ n. of species (%)
Valle d'Aosta	143	618	2,068	23.14	29.88
Piemonte	171	887	3,304	19.28	26.85
Lombardia	171	828	3,017	20.65	27.44
Trentino-Alto Adige	161	756	2,776	21.30	27.23
Veneto	170	878	3,111	19.36	28.22
Friuli-Venezia Giulia	171	885	3,094	19.32	28.60
Liguria	169	879	2,977	19.23	29.53
Emilia-Romagna	165	839	2,609	19.67	32.16
Toscana	174	953	3,249	18.26	29.33
Marche	152	785	2,436	19.36	32.22
Umbria	152	763	2,241	19.92	34.05
Lazio	174	925	3,041	18.81	30.42
Abruzzo	160	862	2,989	18.56	28.84
Molise	141	752	2,308	18.75	32.58
Campania	163	847	2,691	19.24	31.48
Puglia	142	759	2,199	18.71	34.52
Basilicata	142	780	2,501	18.21	31.19
Calabria	148	798	2,513	18.55	31.75
Sicilia	157	859	2,793	18.28	30.76
Sardegna	157	778	2,295	20.18	33.90
Italy	196	1,267	6,711	15.47	18.88

Table 4.4 - Indices of taxonomic diversity for the 20 Italian regions.

	surface (sq km)	n. of units
Valle d'Aosta	3,264	2,174
Piemonte	25,399	3,521
Lombardia	23,859	3,220
Trentino-Alto Adige	13,607	2,985
Veneto	18,365	3,295
Friuli-Venezia Giulia	7,844	3,335
Liguria	5,418	3,131
Emilia-Romagna	22,125	2,726
Toscana	22,992	3,435
Marche	9,693	2,571
Umbria	8,456	2,360
Lazio	17,227	3,228
Abruzzo	10,794	3,232
Molise	4,438	2,412
Campania	13,595	2,844
Puglia	19,357	2,287
Basilicata	9,992	2,636
Calabria	15,080	2,630
Sicilia	25,707	3,011
Sardegna	24,090	2,408
Italy	**301,302**	**7,634**

Table 4.5 - Number of vascular units in the 20 Italian regions (source for the surfaces data: http://www.globalgeografia.com/italia/italia_sup.htm).

	surface (sq km)	n. of species
Albany	28,750	3,200
Switzerland	41,290	3,100
Austria	83,860	3,350
Portugal	92,000	2,850
Hungary	93,030	2,600
Bulgaria	110,910	3,600
ex Czechoslovakhia	127,300	3,050
Greece	131,990	4,150
Romania	235,500	3,600
British Isles	244,800	2,400
Italy	301,302	6,711
Ex-Yugoslavia	256,393	5,075
Poland	311,730	2,350
Norway	323,917	1,500
Finland	377,009	1,350
Germany	353,640	3,050
Sweden	449,531	1,700
Spain	505,545	5,200
France	551,695	5,000
ex-European USSR	5,443,900	4,450

Table 4.6 - Number of vascular plants (species) in the European countries (CRISTOFOLINI, 1998; data updated for Italy following CONTI *et al.*, 2005).

of occurring units should be related to the extent of the surface area of the Region and, moreover, one should remember that these numbers include also the naturalised alien units.

Objective measurements of the floristic richness of a given area, instead, can be obtained by calculating the number of species per unit of surface area, thereby correcting for unequal sample sizes (*i.e.* eliminating sampling artifacts), since the ratio lowers as the surface area increases. Assessments made by the cited Authors indicate that the European countries in which the greatest floristic diversity is concentrated are, in order, Italy, ex-Yugoslavia and Spain (PIGNATTI, 1994; CRISTOFOLINI, 1998). As for the Italian Regions, the data for the European Countries are reported in Table 4.6.

Vulnerable, endemic and rare species of the Italian vascular flora[3]

In 1992 the Red Book of Italian Plants (CONTI *et al.*, 1992) was published, identifying almost 500 *taxa* (more than 6% of the vascular flora) considered as threatened of extinction in Italy (LUCAS & SYNGE, 1978). This publication was a first response at a national level to the increasingly urgent need for protection of Italian flora and was not only a significant step towards achieving greater interpretative uniformity, but also a stimulus to obtaining information about endangered flora in Italy.

Recently the EDEN database (*Enhanced Database of ENdangered species*)[4] (S.B.I., 2000) has supplied further and more precise ecological information of bibliographic kind about the vascular plants included in the Red Book.

In 1997 a new version of the '*IUCN Red List Categories*' (IUCN, 1994) was adopted for the drawing up of the Regional Red List of Italian Plants (CONTI *et al.*, 1997). This important text – which is still in widespread use today –was the outcome of collaboration between the best botanists from across the various regions of Italy. On the

[3] This section edited by Anna Scoppola and Claudia Caporali.

[4] Convention between the Ministry for the Environment Land and Sea Protection and the Protection of the Territory, and the Società Botanica Italiana (Italian Society of Botany) on rare and threatened units of the Italian flora; within the projects *LIFE Natura* LIFE92 NAT/IT/013100 and LIFE94 NAT/IT/001048.

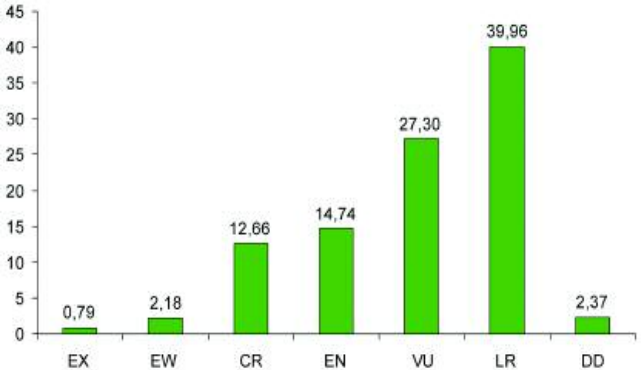

Fig. 4.7 - Distribution of the percentages of the threatened flora (1,011 units) in the IUCN categories.

Fig. 4.8 - *Dianthus rupicola* Biv. *s.s.* (VU in the national Red Book) in Calabria (Photo by G. Spampinato).

Fig. 4.9 - *Aurinia leucadea* (Guss.) C. Koch (EN in the national Red Book) in Puglia (Photo by P. Medagli).

basis of these regional lists the Red Book list of endangered species was extended and reached a total of 1,011 units - about 13% of the Italian vascular flora. Figure 4.7 shows this 13% of *taxa* divided into the following categories: EX: Extinct; EW: Extinct in the Wild; CR: Critically Endangered; EN: Endangered; VU: Vulnerable; LR: Lower Risk: DD: Data Deficient. From the data supplied in the Figure it is apparent that, at the end of the 1990's, there was insufficient information concerning a number of *taxa* (2%).

During the years 2000-2005 - in parallel with the *Checklist of the Italian Vascular Flora* (CONTI *et al.*, 2005)- a thorough updating was undertaken of the distribution areas of a selection of 1,165 units considered to be highly characteristic of Italian vascular flora and regarded as 'vulnerable' (*sensu* IUCN, 1994), 'endemic', 'rare'[5]. These 1,165 units come from the sum of the plants of the 1992 Red Book, the ones of the national extension to the Regional Red Lists (CONTI *et al.*, 1997), the species of Annex II of the Habitat Directive which occur in Italy and a few endemics with restricted distribution area which, in 1995, as the Italian Society of Botany advised the European Union, needed to be included in an extension to Annex II of the Habitat Directive.

These *taxa* became the focus of research for a network of experts, the majority of whom were members of the Italian Society of Botany, under the coordination of the University of Tuscia (Viterbo) (UTV). By means of the detailed, up-to-date knowledge of these experts, it became possible to register over 27,000 records composed either of the latest available bibliographic data from reliable sources, or of verified herbarium data, or of previously unpublished data. Figure 4.10 shows the percentages of these different data-types collected in the various regions. Whether one or another data-type predominates for any given region may depend on the presence there of an important museum and/or library, or of research groups which are particularly active in the local area. The situation in Toscana or Sardegna, for example, is in marked contrast to that in the Marche or Molise and to that in Emilia-Romagna. The data provided and partially summarised in the following Figures lead to some interesting considerations.

Figure 4.11 shows the numbers of units per region, calculated on the basis of their real distribution according to the updated data. Worth noting are the high number of endangered species in the large islands (mostly endemic species with a restricted distribution area), in a few Alpine regions and in Toscana.

Figure 4.12, instead, shows the numbers of species categorized as endangered per region, but whose status may be subject to modification on the basis of more recent

[5] The Catalogue was set up within the Convention between the Ministry of Environment and the Botany Department of the University of Catania (responsible, Prof. G. Giaccone).

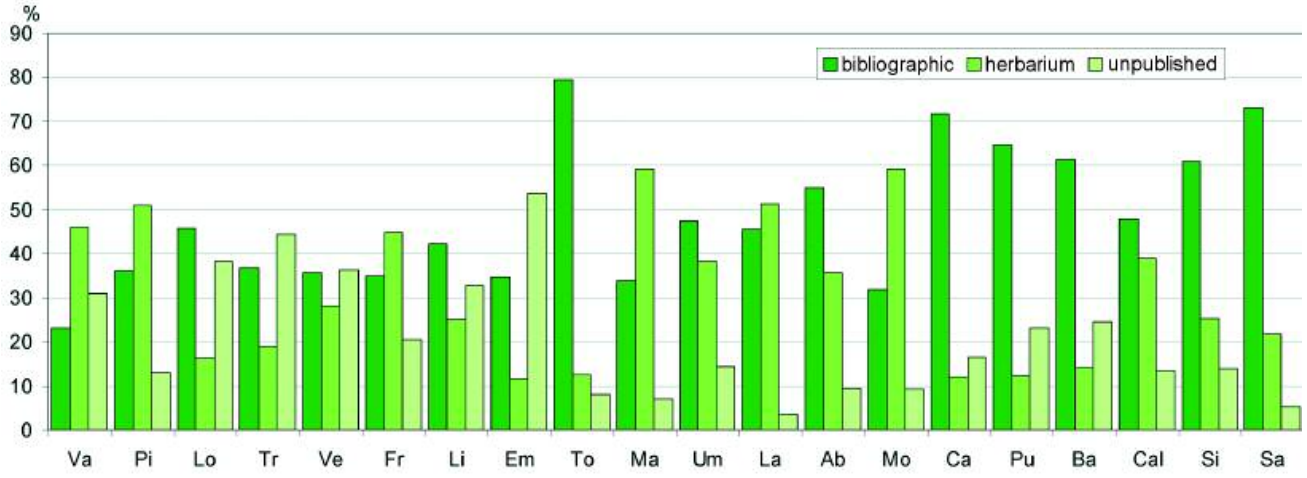

Fig. 4.10 - Percentages of the data per region divided by sources.

studies. Map a) shows the situation regarding the '*inquirenda*' units at the regional level. These are taxa which have not been observed in recent times (sometimes for more than a century – implying they may have already disappeared from the locality), or for which the available distributional data is still insufficient, or for which unresolved taxonomical problems still exist. Map b) shows the situation regarding '*excludenda*' units. This category groups together *taxa* which today are to be excluded from the autochtonous flora of many individual regions, either because they are extinct locally, or because they were mistakenly identified in the past, or confused with *taxa* that are similar, or because they are present today only in cultures. The significant number of units in one or other of these categories in many regions is further confirmation of what has already been recognised by many botanists – that more studies need to be performed on this aspect of the vascular flora, although many people believe it is well known. Actually, it has to be stressed that demonstrating that a species has become extinct is not easy if insufficient data are available for it, and if it is not possible to establish with certainty that its habitat has been destroyed at all known stations. In such cases it would be more correct to speak of *taxa* which are 'no longer found', or are 'possibly extinct'. As regards the link between loss of biodiversity and the extinction of species, it needs to be noted that many of the species that have disappeared from the flora of one region or another, or from the entire national territory are, in general, replaced by similar *taxa* identified by recent and more thorough biosystematic

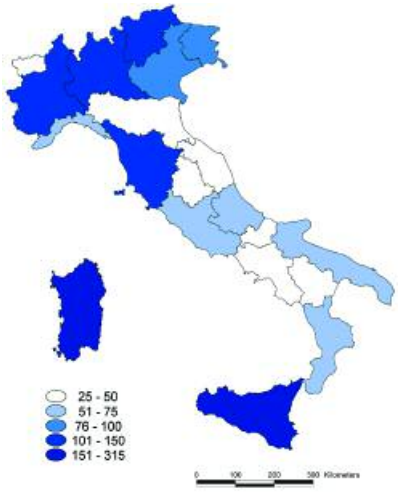

Fig. 4.11 - Number of units of the threatened flora in each region.

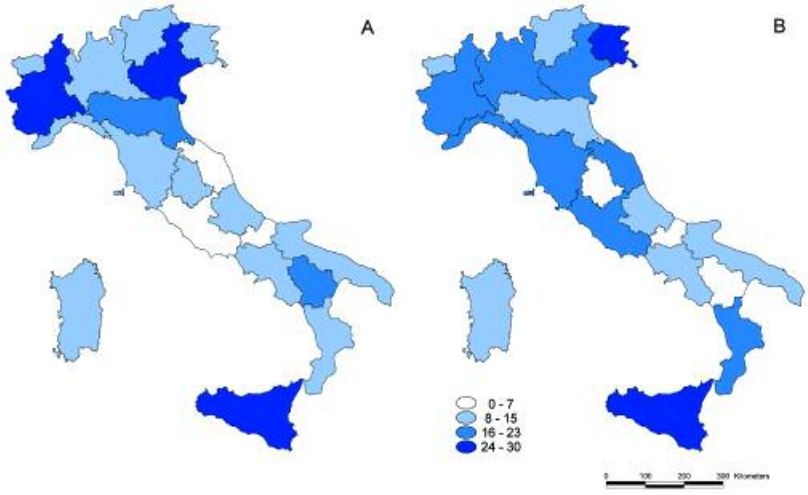

Fig. 4.12 - Amount of the threatened units in the different regions: A – *inquirenda*, B – *excludenda*.

Units extinct at least in the wild		
IUCN status in Italy (1997)		**Regions of provenance of the last distribution data**
EW	*Carex bohemica* Schreb.	Piemonte, Emilia-Romagna
CR	*Apium repens* (Jacq.) Lag	Lombardia, Trentino-Alto Adige, Emilia-Romagna, Abruzzo
EW	*Lythrum thesioides* M.Bieb.	Lombardia,Veneto, Emilia-Romagna
VU	*Sagina nodosa* (L.) Fenzl	Trentino-Alto Adige
EW	*Scilla litardierei* Breistr.	Friuli-Venezia Giulia
VU	*Peucedanum coriaceum* Rchb. var. *pospichalii* Thell.	Friuli-Venezia Giulia
EW	*Astragalus scorpioides* Pourr. ex Willd.	Toscana
EW	*Nepeta italica* L.	Marche
EW	*Nonea obtusifolia* (Willd.) DC.	Lazio
EW	*Trifolium latinum* Sebast.	Lazio
CR	*Bellevalia ciliata* (Cyr.) Nees	Puglia
CR	*Limonium peucetium* Pignatti	Puglia
EW	*Pinus halepensis* Mill. subsp. *brutia* (Ten.) Holmboe	Calabria
EX	*Salvia ceratophylloides* Ardoino	Calabria
EX	*Allium permixtum* Guss. s.s.	Sicilia
EX	*Limonium catanense* (Tineo ex Lojac.) Brullo	Sicilia
EX	*Limonium intermedium* (Guss.) Brœullo	Sicilia
EW	*Potamogeton siculus* Tineo s.s.	Sicilia
CR	*Puccinellia gussonei* Parl.	Sicilia
EW	*Rumex dentatus* L.	Sicilia
EW	*Teucrium creticum* L.	Sicilia
Units reported by mistake		
IUCN status in Italy (1997)		**Regions of provenance of the last recordings**
EX	*Chrysosplenium oppositifolium* L.	Piemonte, Lombardia
LR	*Laser trilobum* (L.) Borkh.	Trentino-Alto Adige
VU	*Utricularia ochroleuca* R.V. Hartm.	Trentino-Alto Adige
VU	*Carex melanostachya* M. Bieb. ex Willd.	Trentino-Alto Adige, Veneto
LR	*Campanula marchesettii* Witasek	Trentino-Alto Adige, Friuli-Venezia Giulia
EN	*Epipactis greuteri* M. Baumann et Künkele	Veneto, Emilia-Romagna, Toscana
LR	*Limonium savianum* Pignatti	Toscana
EW	*Sesleria tuzsonii* Ujhelyi	Toscana
LR	*Umbilicus erectus* DC. [= *U. luteus* (Huds.) Webb. et Berthel.]	Abruzzo, Puglia, Calabria
VU	*Allium aethusanum* Garbari	Sicilia
LR	*Anthemis urvilleana* (DC.) Sommier et Car.-G.	Sicilia
LR	*Asparagus aetnensis* Tornab.	Sicilia
LR	*Limonium exaristatum* (Murb.) P. Fourn.	Sicilia
LR	*Spergula morisonii* Boreau	Sicilia
DD	*Saxifraga carpetana* Boiss. et Reut. subsp. *carpetana*	Sicilia
DD	*Iris todaroana* Cif. et Giacom.	Sicilia, Sardegna

Table 4.7 - Units to be excluded from the Italian flora, because not observed for a long time or reported by mistake.

studies (PIGNATTI *et al.*, 2001). Thus, in reality it is the names of *taxa* which are disappearing, while the 'genetic pool' of the Italian floristic patrimony remains virtually unchanged.

Among the '*excludenda*', the species which are to be considered as 'critical' - and therefore deserving of more careful investigation - are above all those which turn out to be critical in every one of the regions where they have been recorded as occurring to date (Table 4.7). In fact, the exclusion of a species from regional flora immediately leads to a loss of biodiversity at the national level. Belonging to this group are to be found, among others, *Api-*

um repens (Jacq.) Lag., now disappeared from Trentino-Alto Adige, Emilia-Romagna and Abruzzo and with an old report for Lombardia to be probably considered a mistake, *Peucedanum coriaceum* Rchb. var. *pospichalii* Thell., *Bellevalia ciliata* (Cyr.) Nees., *Limonium peucetium* Pignatti, *Puccinellia gussonei* Parl., *Sagina nodosa* (L.) Fenzl, which in CONTI *et al.* (1992, 1997) were placed within different categories. Two species for which, in the past, there was a lack of definite data (DD), *Saxifraga carpetana* Boiss. Et Reut. Subsp. *carpetana* and *Iris todaroana* Cif. et Giacom., are now to be excluded from the Italian flora because it has now been established that they were mistakenly identified. In fact, some of the above units are no longer cited for Italian national territory in some authoritative Flora (*Med Checklist*, *Flora Europaea* etc.).

Table 4.8 shows units which are '*inquirenda*' for the entire Italian territory, about which there is still insufficient information and for which it appears that further checking and updating of the data are essential. In some cases this concerns units which have been incorrectly described and whose precise identity is still uncertain - thus as a result they have been little observed.

Consequently, to confirm whether or not a unit has indeed disappeared, superficial or occasional identification of it at known sites is not sufficient. Instead, rigorous monitoring, capable of providing statistically valid data through time, needs to be set up (PIGNATTI *et al.*, 2001). Some presumed extinctions in one or more regions may, in the future, be disproved thanks to progress in information gathering systems.

It was precisely to such an end that an in-depth study was carried out on the 77 units of Annex II of the Habitat Directive 92/43. Figure 4.13 shows the distribution of these units by region: no less than 32 are priority *taxa* (Table 4.9) and over 75% are endemics. To be noted is the total absence of species in Marche, while the situation in Sardegna and Sicilia is particularly indicative. On these islands numerous units are concentrated which, as well as being priority, are also endemic and of restricted distribution area – for example *Abies nebrodensis* (Lojac.) Mattei, *Leontodon siculus* (Guss.) R.A. Finch et P.D. Sell, *Aster sorrentini* (Tod.) Lojac. in Sicilia, *Astragalus maritimus* Moris, *Centaurea horrida* Badarò, *Anchusa crispa* Viv. in Sardegna.

Many of these units should be investigated in several regions, for they have not been found there since a long time; two of them, in particular, *Gypsophila papillosa* Porta in Trentino-Alto Adige (VU in the Red List) and *Saxifraga hirculus* L. in Valle d'Aosta (DD in the Red List) would merit further study, since their current distribution is still not known.

As suggested by the IUCN (IUCN, 1994; WALTER & GILLET, 1998), and by others (RIZZOTTO, 1996; PIGNATTI *et al.*, 2001), this updating of the distributional data should be followed by a re-examination of the units using the new criteria for assessing the degree of threat and of the most recent surveys. This would be particularly important for *taxa* placed in the 'endangered' categories (CR, EN, VU) or 'Lower Risk' (LR). Among such *taxa* are: *Lindernia procumbens* (Krock.) Philcox, *Carex stenophylla* Wahlenb., *Schoenoplectus supinus* (L.) Palla and others. It would also be important for 'endangered' *taxa* whose

Asparagus pastorianus Webb et Berth.
Carex juncella (Fr.) Th. Fr.
Carthamus dentatus Vahl
Centaurea africana Lam.
Christella dentata (Forssk.) Brownsey et Jermy
Dactylorhiza praetermissa (Druce) Soó
Hieracium pavichi Heuff.
Iberis linifolia L. subsp. *stricta* (Jord.) P. Fourn.
Linum catanense Strobl.
Malcolmia africana (L.) R. Br.
Pedicularis sylvatica L.
Saxifraga hirculus L.
Silene turbinata Guss.
Spergularia tunetana (Maire) Jalas
Stachys brachyclada De Noé

Table 4.8 - '*Inquirenda*' *taxa* at national level.

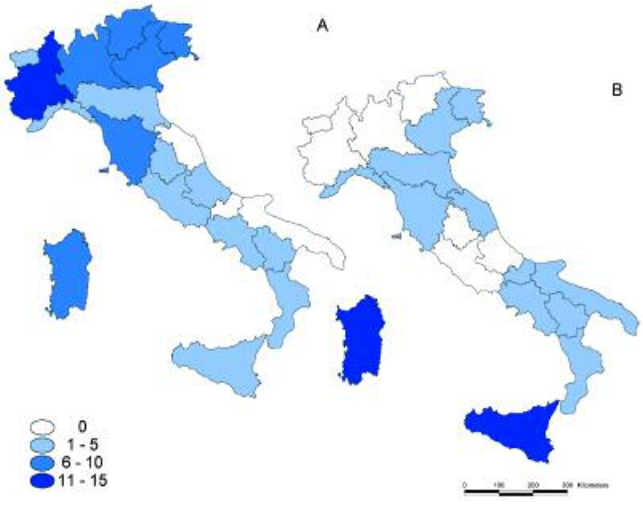

Fig. 4.13 - Units (A) and priority units (B) of the Annex II of the Habitat Directive per region.

Gimnosperms
Abies nebrodensis (Lojac.) Mattei
Angiosperms Dicotyledons
Anchusa crispa Viv.
Armeria helodes Martini et Poldini
Aster sorrentinii (Tod.) Lojac.
Astragalus aquilanus Anzalone
Astragalus maritimus Moris
Astragalus verrucosus Moris
Bassia saxicola (Guss.) A.J. Schott
Brassica macrocarpa Guss.
Campanula sabatia De Not.
Centaurea horrida Badarò
Cytisus aeolicus Lindl.
Euphrasia genargentea (Feoli) Diana Corrias
Galium litorale Guss.
Gypsophila papillosa Porta
Herniaria litardierei (Gamisans) Greuter & Burdet
Lamyropsis microcephala (Moris) Dittrich et Greuter
Leontodon siculus (Guss.) R.A. Finch et P.D. Sell
Limonium insulare (Bég. et Landi) Arrigoni et Diana
Limonium pseudolaetum Arrigoni et Diana
Limonium strictissimum (Salzm.) Arrigoni
Linum muelleri Moris
Primula pedemontana Gaudin subsp. *apennina* (Widmer) Kress
Ribes sardoum Martelli
Salicornia veneta Pignatti et Lausi
Silene hicesiae Brullo et Signorello
Silene velutina Loisel.
Angiosperms Monocotyledons
Carex panormitana Guss.
Muscari gussonei (Parl.) Tod.
Ophrys lunulata Parl.
Stipa austroitalica Martinovsky
Stipa veneta Moraldo

Table 4.9 - Priority species of the Annex II of the Habitat Directive occurring in Italy.

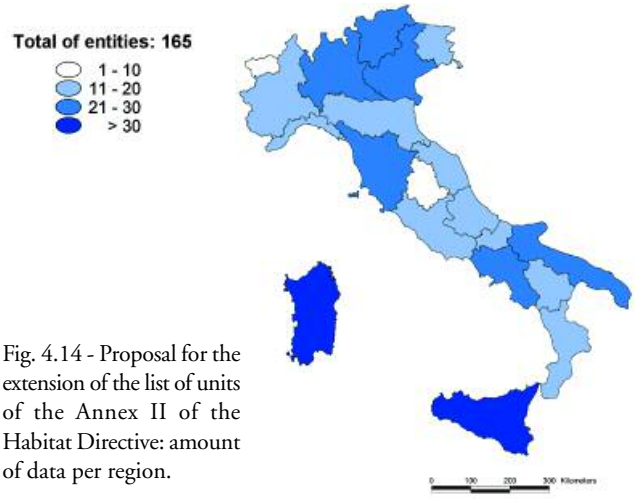

Fig. 4.14 - Proposal for the extension of the list of units of the Annex II of the Habitat Directive: amount of data per region.

situation is progressively becoming more severe, such as *Caldesia parnassifolia* (L.) Parl., *Silene linicola* C.C. Gmel. and *Aldrovanda vesiculosa* L. In Italy a first contribution in this is represented by the work by GIOVI *et al.* (2003), who considered the status of 8 units taken from CONTI *et al.* (1997) (CR: *Adonis vernalis* L., *Iris setina* Colasante; EN: *Malcolmia littorea* (L.) R. Br.; VU: *Isoëtes velata* A. Braun subsp. *velata*, *Astragalus aquilanus* Anzalone, *Vicia sativa* L. subsp. *incisa* (M. Bieb.) Arcang., *Goniolimon italicum* Tammaro, Frizzi et Pignatti; LR: *Acer cappadocicum* Gled. subsp. *lobelii* (Ten.) Murray) to assess the extent of application for the Italian flora of the new IUCN criteria.

Moreover, the status needs to be re-assessed of some units which were not considered in the past, but which, in the light of the present and other recent studies (SBI, 2000; ABBATE *et al.*, 2001, PIGNATTI *et al.*, 2001, PROSSER, 2001, etc.), would merit greater attention. This is the case regarding *Dianthus ferrugineus* Miller, *Erinus alpinus* L., *Romulea requienii* Parl., *Crocus minimus* DC., *Polygala apiculata* Porta and many other units. In this regard, an example, even if it is one which is limited to too restricted a number of species, is provided by the volume on the Red and Blue lists of Italian flora, edited by the ANPA (today APAT) (PIGNATTI *et al.*, 2001).

Out of the species that are to be proposed for an extension to Annex II of the Habitat Directive, 165 (easily the larger portion of which is made up of endemics - about 75%) are distributed among the various regions as shown in Figure 4.14 - Sicilia and Sardegna are again the richest regions. Nevertheless, despite the in-depth studies carried out over recent years, for 23 of these units some doubt still exists over whether they are actually present in one or other of the regions (Table 4.10). Worth pointing out among these more critical species are *Pilularia minuta* Durieu ex Braun (VU in the Red List), which has already disappeared from Lazio and Sicilia and has not been found in Sardegna for more than a century, and *Wulfenia carinthiaca* Jacq. (EN in the Red List), known for Friuli-Venezia Giulia, where, however, it has not been found for over 50 years, despite repeated searches.

The data collected up to 2003 thanks to the support of the Ministry for the Environment Land and Sea Protection and the Protection of the Territory, Nature Conservation Direction, and afterwards updated within the editing program of the Flora Working Group of the Società Botanica Italiana *Atlante delle specie a rischio di estinzione in Italia* (Atlas of threatened vascular plants of Italy), dealing with the 1,011 units of the national Red List, are available on CD-rom (SCOPPOLA & SPAMPINATO (Eds.), 2005).

Anagallis monelli L.
Anagallis tenella (L.) L.
Artemisia petrosa (Baumg.) Jan subsp. *eriantha* (Ten.) Giacomini et Pignatti
Biscutella cichoriifolia Loisel.
Carex liparocarpos Gaudin subsp. *liparocarpos*
Centaurea centaurioides L.
Dactylorhiza traunsteineri (Saut. ex Rchb.) Soó
Euphorbia villosa Wald. et Kit.
Iberis semperflorens L.
Lycopodiella inundata (L.) Holub
Menyanthes trifoliata L.
Myosotis speluncicola (Boiss.) Rouy
Paeonia mascula ssp. *russoi* (Biv.) Cullen et Heyw.
Pilularia minuta Durieu ex A. Braun
Polygala exilis DC.
Potamogeton coloratus Vahl
Rhynchocoris elephas (L.) Griseb.
Senecio doria L.
Sesleria italica (Pamp.) Ujhelyi
Stachys maritima Gouan
Vicia barbazitae Ten. et Guss.
Viola aethnensis Parl. subsp. *splendida* (W. Becker) Merxm. et Lippert
Wulfenia carinthiaca Jacq.

Table 4.10 - Extension proposed by the Italian Society of Botany of the Annex II of the Habitat Directive: units with insufficient data.

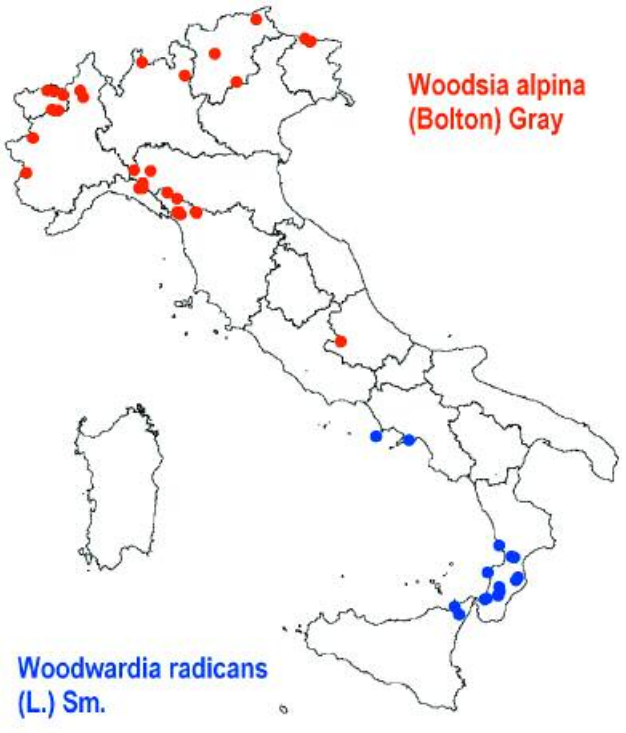

Fig. 4.15 - Example of distribution maps that can be drawn from the recorded data.

These data will form an important reference source for researchers and administrators and will be indispensable for the analysis of both the floristic trends in Italian national territory and the validity of choices made in drawing up the lists of species in the Red lists and the extension to Annex II of the Habitat Directive 92/43.

The documentation produced is clearly of enormous value, even if it does require periodic updates. As was pointed out earlier, in fact, this is neither the first, nor is it the only, update of the endangered species of Italian vascular flora to be carried out in recent years. However this study is certainly to be distinguished from all previous studies, in that it set out with the explicit intention of going back to the original source of each distributional datum, reconsidering its exact dating (SCOPPOLA *et al.*, 2003).

The widespread availability of these data will enable ever increasing numbers of conservation projects *in situ* to be gotten under way - projects which too often, in the past, have been halted in the embryonic stages, owing to lack of information on the exact distribution of species and their autecological characteristics.

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BRYOPHYTES

[Michele Aleffi]

The bryophytes, together with the tracheophytes, are adapted primarily to terrestrial living and - marine environments excepted – are to be found everywhere on earth. Owing to the microscopic dimensions of their spores and to their frequently vegetative reproduction, bryophytes, in fact, spread with ease through the environment.

Sexual reproduction in these plants takes place in alternate generations, where the autotrophic gametophyte dominates over the sporophyte. After fertilization the zygote develops into an embryo *(Embryophyta)*. This develops into the sporophyte, in which caulidium, phylloids and rhizoids are distinguished, that fix the plant to the substrate.

The bryophytes include around 24,000 species on earth and these can be divided into three groups (classes), which are clearly separated phylogenetically: *Anthocerotopsida, Marchantiopsida*, *Bryopsida*. *Anthocerotopsida* form a minor group of around 100 species (of which only 6 occur in Italy). These species are to be considered relicts going back to the beginnings of the phylogenetic history of bryophytes, which are grouped together within the single order *Anthocerothales*. The *Marchantiopsida* class is represented by the *Hepaticae*, divided into *Marchantiidae* and *Jungermanniidae*. The third class is represented by the *Bryopsida* or *Musci,* which comprise the Mosses, subdivided into *Sphagnidae* (with the single family *Sphagnaceae*), *Andreaeidae* (with the single family *Andreaeaceae*) and *Bryidae*, which are the most numerous group with about 15,000 species divided into numerous orders and families.

Bryological research in Italy

From the beginning of the eighteenth century to the present days, bryological research in Italy has made remarkable progress. Nevertheless, it has to be pointed out that for many years *Flora Italica Cryptogama* by ZODDA (1934) and *Syllabus Bryophytarum Italicarum* by GIACOMINI (1947), were the only bibliographical references available. Until, that is, the recent publication of two Checklists: CORTINI PEDROTTI (1992, 2001b), regarding Mosses, and ALEFFI & SCHUMACKER (1995), regarding liverworts.

The last few years, in particular, have seen a marked acceleration in progress. As regards Moss species, in the last decade alone (starting, that is, from the date of publication of the first Checklist for Mosses) the number of *taxa* has risen from 818 to 851. This increase is due mainly to the intensification of research in those areas of Italy which, hitherto, had been either totally unexplored, or only partially explored, from the bryological standpoint.

Table 4.11 indicates the changes in numbers of Moss species recorded for the different regions of Italy, between 1992 and 2000. The biggest increase for Abruzzo was due, in part, to a ten-day field-trip conducted in various significant locations and environments of the mountainous areas of the region (MASTRACCI & DÜLL, 1991). It was also due, in part, to an investigation carried out on the bryological flora of the Monti della Laga, which fall largely within the borders of the Abruzzo Region (ALEFFI *et al.*, 1997b).

Regions	1992	2000	difference
Val d'Aosta	341	360	19
Piemonte	578	587	9
Lombardia	658	669	11
Trentino-Alto Adige	670	683	13
Veneto	470	483	13
Friuli-Venezia Giulia	461	473	12
Liguria	323	321	-2
Emilia-Romagna	388	391	3
Toscana	480	483	3
Marche	244	249	5
Umbria	155	179	24
Lazio	369	371	2
Abruzzo	195	271	76
Molise	153	160	7
Campania	283	317	34
Puglia	187	184	-3
Basilicata	148	150	2
Calabria	231	254	23
Sardegna	343	346	3
Sicilia	372	389	17

Table 4.11 - Consistency and increase of the number of bryophyte species in the Italian regions.

The first bryological field-trip made by the Bryology Working Group of the Italian Society of Botany led to the identification of no less than 34 species (27 Mosses and 7 Liverworts) which are new for the region (CORTINI PEDROTTI *et al.*, 1993).

As regards Umbria, significant increases in bryological knowledge resulted from two important studies of acidophilous plain woods, one on those bordering Lake Trasimeno (ALEFFI, 1992a), the other on those of the lacustral basin of Gubbio (ALEFFI, 1992b).

Equally worthy of note, were a series of research projects undertaken in the southern part of Aspromonte, in Calabria, between 1994 and 1996. These led to the recognition of numerous species which were new for Calabria (PUGLISI, 1994a, 1994b, 1995; PRIVITERA & PUGLISI, 1995a, 1995b, 1996) and this highlights the need for in-depth bryological studies, even in areas which have already been repeatedly explored.

In Valle d'Aosta, too, important studies have been performed in recent years – in the Valle di Champorcher (MISERERE *et al.*, 1995), in the wetlands of the Mt. Avic Regional Natural Park (MISERERE *et al.*, 1996) and in the Gran Paradiso National Park (SCHUMACKER *et al.*, 1999).

As for Sicilia, researchers from the Universities of Catania and Palermo have conducted several important investigations, identifying species which are new not only for Sicilia, but also for Italy (RAIMONDO & DIA, 1997; CARRATELLO & ALEFFI, 1998, 1999; PRIVITERA & PUGLISI, 1997, 1998, 1999).

This intensification of bryological exploration has been matched by a significant increase in scientific publications. The first updating of the *Bibliografia Briologica d'Italia* (Bryological Bibliography of Italy) (CORTINI PEDROTTI, 1996a), which covers the period from 1985 to 1994, consisted of 292 bibliographic entries. This serves to demonstrate the continuous and ever increasing interest in bryological research of a, by now, quite well-consolidated group of Italian botanists.

Italian bryological flora

On the basis of the data provided by the two Checklists - CORTINI PEDROTTI (1992, 2001b) on Mosses and ALEFFI and SCHUMACKER (1995) on Liverworts, the Italian bryological flora consists (not counting subspecies and varieties) of 1,130 species, subdivided as follows:

- Liverworts: 279 species (divided into 81 genera and 40 families)
- Mosses: 851 species (divided into 210 genera and 55 families)

In terms of bryological flora Italy is, without doubt, one of the richest regions of Europe. It has about two thirds of the European bryological flora, composed of 1,690 bryophyte species, of which 1,084 are Mosses. The German bryological flora, in contrast, consists of 1,051 species (247 Liverworts and 804 Mosses), while the bryological flora of the British Isles consists of a total of 1,000 species (284 Liverworts and 716 Mosses). Examining other Mediterranean countries, progressively lower numbers of bryophytes can be observed, with the sole exception of Spain, which has 1,020 species (279 Liverworts and 741 Mosses).

The numbers of bryophytes cited for Italy are, anyway, sure to be subject to continual modifications and updates, as new species are added at both national and regional levels and as bryological research progresses, especially in those areas of Italy that are still totally unexplored from a bryological standpoint.

Essentially, Italy owes its high floristic diversity to certain of its geographical features: 1) the presence of the Alpine range which, owing to its geomorphological and geological complexity and to its length, produces a great variety of mesoclimates; 2) its unique position in the centre of the Mediterranean basin; 3) the presence of the Apennine chain, orientated north-south along the entire length of the peninsula, like a backbone; 4) the presence of high mountain massifs in the south of the peninsula, in the full Mediterranean zone.

Finally, the finding of such a large number of species which are new, not only for various individual regions of Italy, but also for Italian national territory as a whole, in itself represents an important contribution in floristic terms. Beyond this, however, it also provides an opportunity for new, in-depth studies to be performed on the ecology and chorology of these species - and of the biogeographical aspects of the Italian bryological flora in general.

The Check-list and the Red-List of the Italian bryophytes

During compilation of the *Check-list of the Mosses of Italy* (CORTINI PEDROTTI, l.c.) and of the *Check-list and red-list of the liverworts (Marchantiophyta) and liverworts (Anthocerotophyta) of Italy* (ALEFFI & SCHUMACKER, l.c.) some problems of a taxonomical and nomenclatural nature became evident. Only recently has the revision of some critical families and genera made it possible to resolve these problems. Among the Liverworts, a classic example is *Calypogeia trichomanis* auct. At least 5 different species can be found under this name (especially in the old Herbarium collections and in bibliographical citations often dating back to the end of the nineteenth century): *C. azurea*, *C. fissa*, *C. neesiana*, *C. integristipula*, *C. muelleriana*. In automatically identifying *Calypogeia trichomanis* as *C. azurea*, numerous authors created taxonomical and nomenclatural confusion in the literature. It only became possible to correct this error during com-

pilation of the Checklist of the Liverworts, by means of a revision of Herbarium specimens (ALEFFI & SCHUMACKER, 1997).

Many examples of similar confusion can be cited, both among Liverworts and among Mosses. It was the case with genera such as *Anthoceros*, *Jungermannia*, *Lophozia*, *Plagiochila*, *Porella*, *Scapania* sect. *Curtae* and *Marchantia polymorpha* complex among the liverworts. Among the mosses, to be noted are the genera *Grimmia*, *Orthotrichum*, *Schistidium*, *Hedwigia*, *Sphagnum*, *Tortula*, the family *Mniaceae*, the *Bryaceae* and, in particular, the *Bryum bicolor* complex and the *Hypnum cupressiforme* complex – most of which were brought to light during the compilation of *Flora dei Muschi d'Italia* (CORTINI PEDROTTI, 2001a). In all of these cases, the only way of accurately assessing the veracity of bibliographical citations was by performing a revision of herbarium specimens. This, however, was much more complex than might be imagined. The majority of specimens were collected around the mid-1800's and it was often extremely difficult to carry out revision on such old items – given, in the first place, that they can even still be retraced in the historical collections. In fact, the state of conservation of many bryological collections is extremely poor, owing – in the main - to a lack, among herbarium staff, of bryology specialists capable of cataloguing and conserving specimens competently (Figure 4.16).

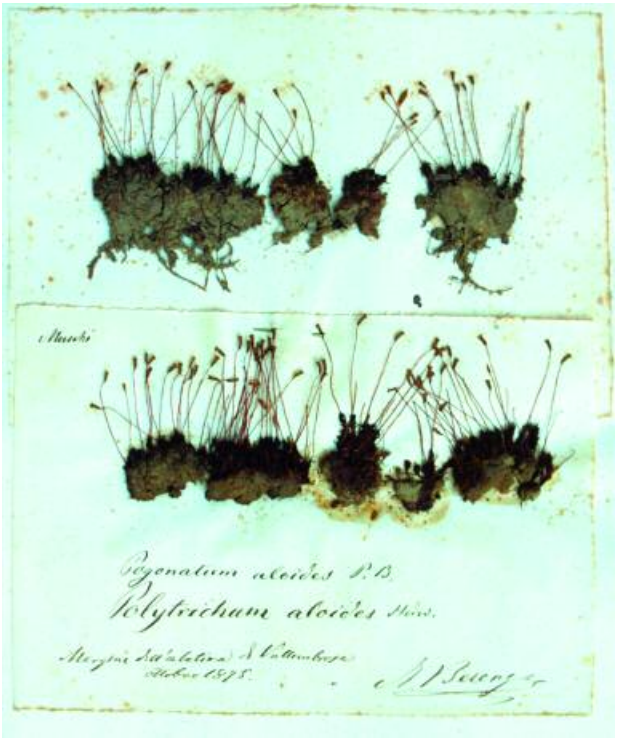

Fig. 4.16 - Two specimens coming from the Herbarium of the Natural History Museum of the Museo Arcivescovile di Perugia. Many of these bryological collections are in an awful state, above all because there are no qualified bryologists who apply themselves to their conservation.

Another problem, and one which is particularly topical, concerns the species included in the successive updates to the national and regional Red Lists and, finally, in Annex II of the Habitat Directive, which is aimed at the conservation of the natural and semi-natural habitats of wild flora and fauna. The Directive lists species considered as endangered and for the safeguard of which the designation of special areas of conservation is indispensable. This list includes 29 Bryophytes, of which 11 are present in Italy, namely: *Buxbaumia viridis*, *Dichelyma capillaceum*, *Dicranum viride*, *Hamatocaulis vernicosus*, *Mannia triandra*, *Meesia longiseta*, *Nothothylas orbicularis*, *Orthotrichum rogeri*, *Petalophyllum ralfsii*, *Riccia breidleri*, *Scapania massalongi*.

In general, these are species for which reports are either very old, or are for one single site only, or are for occurrence in habitats which are at high risk of extinction, such as alpine lakes, wetlands and sand dunes (Figure 4.17). However, there are many other species which are endangered and which should be included in Red Lists aimed at protecting the environments in which they grow. On the basis of bibliographical data alone, in the *Lista Rossa delle Briofite d'Italia* (CORTINI PEDROTTI & ALEFFI, 1992b), no less than 129 liverwort species and 367 moss species are considered as endangered. This is either because they were identified during the late1800's or early 1900's, and have not been found since, or because their distribution areas are confined to a single site, or are fragmented, and occur in environments which are often subject to intense exploitation for tourism (above all the Alps and the coasts). A good example is *Dumortiera hirsuta*, a thallose liverwort of tropical origin which is considered a Tertiary relict and which has taken refuge in a few stations which are, in their turn, themselves relicts of *Woodwardia radicans* – a rare fern which is tropical, too. Only very few stations of *Woodwardia radicans* are known, and some of these have already disappeared as a result of deforestation and the disruption of the environments in which the two plants live.

Some remarks on the bryological biodiversity in Italy

In order to obtain a picture of bryological biodiversity in the Italian peninsula which is concise, but at the same time as complete as possible, it is of particular in-

Fig. 4.17 - The alpine pools and, in general, wetlands are above all threatened by pollution and growing human impact. Yet they house very interesting species, like the rare liverwort *Riccia breidleri*, endemic to the alpine arc, which grows on the shores of such pools.

terest first of all to analyse some chorological aspects which characterise it. For each *taxon* the chorotype has been considered according to the nomenclature established by DÜLL (1983, 1984-1985). In Figure 4.18 the various chorotypes have been brought together, taking into account their similarities, into 12 main groups, after SÉRGIO *et al.* (1994), together with the number and the percentage of species belonging to each of these groups.

An examination of Figure 4.18, which shows the chorological spectra of the two classes combined in the same histogram, reveals that the boreal chorotype predominates, both among the Mosses (24%) and, to a lesser extent, also among the Liverworts (20.9%). This is a group of species that occurs not only in the Alps, but also on the highest peaks of the Apennines, in Sardegna (on the Gennargentu) and in Sicilia (on Etna and the Madonie). It is reasonable to expect that the percentage of the boreal chorotype is destined to increase as research progresses in those areas of the Apennines which are yet to be fully explored. Noteworthy – especially among the liverworts – is the presence of the suboceanic chorotype (15.4%). These are species which have great need for humidity and as a consequence have a distribution area where a temperate-humid climate prevails – i.e the Atlantic parts of Europe and extending as far as the islands of Macaronesia.

The subartic-subalpine chorotype also occurs in extremely significant numbers, both among the Mosses (15.3%) and among the Liverworts (10.2%), Taken together, the subartic-subalpine and artic-alpine chorotypes comprise almost 20% of the entire Italian bryological flora. The large numbers of the subartic-subalpine chorotype are primarily the result of the considerable extension of the alpine environment and are also linked to the better state of conservation of this environment compared to other environments in the Italian peninsula. Nevertheless, the subartic-subalpine chorotype includes many species which can be found along the entire length of the Apennine chain, and in this case, too, the number of such species is destined to increase as research progresses in these areas. The oceanic-mediterranean chorotype, which marks the transition from regions with a typically Mediterranean climate to regions subject to Atlantic climatic influence, is well-represented both among the Liverworts (12.9%) and among the Mosses (10.4%). This chorotype is very important from a bryogeographical point of view, since it includes several species which have a disjunct distribution, or which display relictual characteristics.

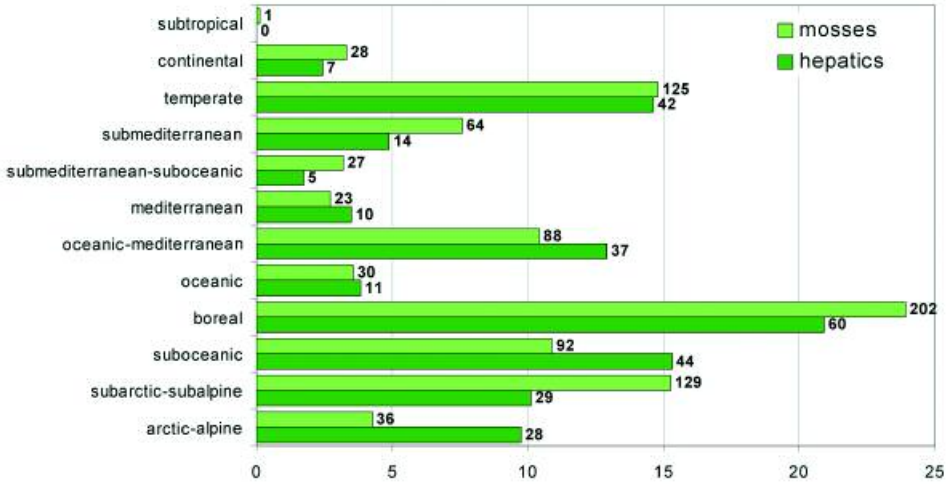

Fig. 4.18 - Chorological spectrum of the Italian Bryophytes (in the histogram bars are reported absolute values).

If we consider the distributional map for Italy of the orders *Quercetalia ilicis* and *Pistacio lentisci-Rhamnetalia alterni,* compiled by PEDROTTI (1996) using a geobotanical criterion, Italy belongs to two phytogeographical regions - Eurosiberian and Mediterranean. Most of the surface area of Italy belongs to the Eurosiberian zone, while the Mediterranean zone is limited to the coastal belt, which on the Adriatic side begins to the south of Pescara and then extends along the Tyrrhenian side as far as the frontier with France, apart from a gap in the vicinity of Genova.

Nevertheless, it has to be pointed out that communities of *Quercus ilex* (some of which are extensive, others less so) occur in stations which are edaphically favourable in some internal parts of central Italy. Even if these *Quercus ilex* communities are to be considered as occurring outside the distribution area, they indicate that a Mediterranean-type climate, however attenuated it may be, occurs in internal zones, too. Some valleys in the Alps with north-south orientation also provide an immigration route for Mediterranean and sub-Mediterranean species, as was demonstrated by bioclimatic analysis performed along a stretch of the Val d'Adige (ALEFFI *et al.*, 1997a).

The extremely variable environmental conditions occurring across Italy, accentuated by the multiplicity of substrates that are to be found, inevitably becomes reflected in bryological richness and diversity throughout the various regions of the country.

Table 4.12 shows this bryological richness and diversity region by region. The various columns give: the number of *taxa* (liverworts plus mosses); this number as a percentage of the total Italian bryological flora (1,130 *taxa*); the surface area of each region in square kilometres; and the ratio between the number of *taxa* and the surface area. Regions are listed in decreasing order of their number of *taxa*, independently of the size of their surface area.

Regions	N. of species	%	Surface (sq. km)	n. of taxa/sq km
Trentino-Alto Adige	904	80.5	13,613	0.066
Lombardia	853	75.9	23,835	0.036
Piemonte	785	69.9	25,399	0.031
Toscana	660	58.8	22,992	0.029
Veneto	632	56.3	18,369	0.034
Friuli-Venezia Giulia	607	54.0	7,845	0.077
Valle d'Aosta	521	46.4	3,262	0.160
Sicilia	506	45.0	25,709	0.020
Lazio	480	42.7	17,202	0.028
Emilia-Romagna	472	42.0	22,122	0.021
Sardegna	425	37.8	24,090	0.018
Campania	407	36.2	13,596	0.030
Liguria	391	34.8	5,413	0.072
Abruzzo	356	31.7	10,794	0.033
Calabria	336	29.9	15,080	0.022
Marche	312	27.8	9,691	0.032
Umbria	233	20.7	8,456	0.028
Puglia	221	19.7	19,347	0.011
Molise	181	16.1	4,438	0.041
Basilicata	169	15.0	9,992	0.017

Table 4.12 - Bryological richness and diversity in the Italian regions.

From the Table it can be seen that the regions which are richest in floristic terms are Trentino-Alto Adige, Lombardia and Piemonte. Within the borders of these regions are to be found the highest peaks of the Alps and a great variety of substrates – moreover, they are also subject to a wide range of climatic influences, from Mediterranean to Continental. In contrast, the regions of Veneto and Friuli-Venezia Giulia – even if they, too, have part of the Alpine range within their borders – exhibit lower numbers of taxa. This is probably the result of the uniformi-

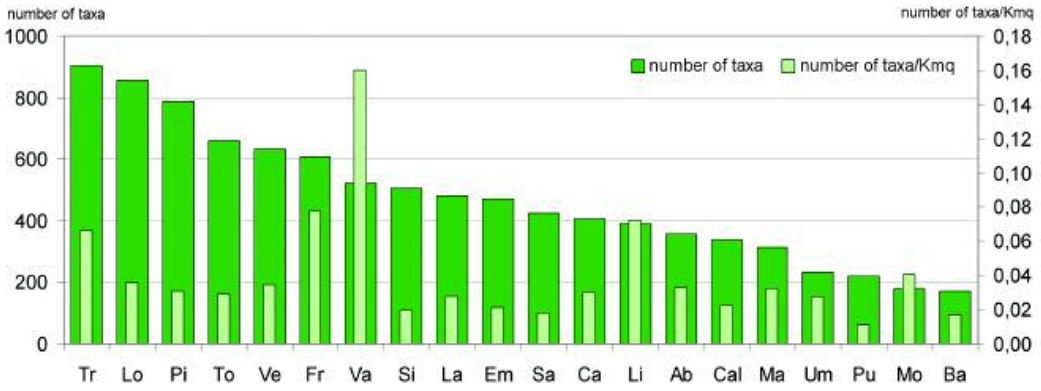

Fig. 4.19 - Bryological richness (number of *taxa*) and diversity (Number of *taxa*/sq km) of each Italian region.

Chorological element	A	B	C	D	E	F	G	H	I	L	M	N	Tot.
Va	33	85	55	172	6	17	1	7	30	105	14		525
Pi	32	95	96	223	16	56	7	21	56	151	27		780
Lo	37	119	95	234	19	71	16	28	59	150	24		852
Tr	47	141	109	250	16	52	14	26	59	157	28		899
Ve	15	83	61	190	9	46	6	15	48	133	19		625
Fr	23	75	62	196	8	35	5	18	39	127	14		602
Li		18	34	96	6	57	10	21	36	107	6		391
Em	4	33	45	143	7	38	4	19	34	127	14		468
To	5	42	80	165	18	92	22	24	53	144	12		657
Ma		6	29	66	4	36	5	15	33	108	6		308
Um		3	17	39	5	36	4	11	24	90	3		232
La	3	22	42	114	7	75	18	22	42	124	8		477
Ab	6	32	29	98	1	25	5	14	29	104	10		353
Mo		11	11	47	3	10	1	6	16	64	5		174
Ca		12	32	68	3	76	19	23	46	117	7	1	404
Pu		3	14	42	1	37	8	15	23	74	2		219
Ba		2	8	27		23	3	12	24	67	2		168
Cal	2	6	28	74	5	52	17	17	31	100	4		336
Si	1	15	35	72	5	80	25	21	50	105	5		414
Sa	4	12	43	97	9	84	24	27	54	128	10	1	493
Tot.	**212**	**815**	**925**	**2,413**	**148**	**998**	**214**	**362**	**786**	**2,282**	**220**	**2**	

Table 4.13 - The chorological elements in the Italian regions: A: arctic-alpine; B: sub-arctic/sub-alpine; C: sub-oceanic; D: boreal; E: oceanic; F: oceanic-mediterranean; G: mediterranean; H: sub-mediterranean/sub-oceanic; I: sub-mediterranean; L: temperate; M: continental; N: sub-tropical.

ty of their substrates, which are largely calcareous (Cortini Pedrotti, 1996b; Aleffi *et al.*, l.c.).

Among the Apennine regions, Toscana exhibits the greatest floristic variety, owing to the considerable variability in its environments from both the geological and climatic points of view. This contrasts with the situation in the other regions of the central and southern Apennines where, as a result of greater edaphic uniformity, the numbers of *taxa* are markedly lower. The two major islands, Sardegna and Sicilia are, however, exceptions, in that the high numbers of taxa to be found are, in part, the consequence of the presence of large mountainous massifs, such as Etna and the Madonie in Sicilia (Dia & Not, 1991) and the Gennargentu and the Limbara in Sardegna (Bischler & Jovet-Ast, 1971-72; Cogoni *et al.*, 1999).

It must, of course, be pointed out that the number of *taxa* provided for any given region is also a function of the state of floristic knowledge for that region. In fact, the extent to which regional territory has been explored varies greatly from one region to another.

Figure 4.19 shows the diversity index (calculated on the basis of the ratio between the number of *taxa* and the surface area) and highlights more effectively the bryological diversity in some regions, independently of the number of *taxa* that are present. From the Figure, it is evident that the Valle d'Aosta is the region with the greatest biodiversity, while Puglia is the region with the lowest biodiversity, as a result of its large surface area compared to the relatively low number of taxa present. Biodiversity levels are also shown to be rather high in Friuli-Venezia Giulia, Trentino-Alto Adige and Liguria.

Table 4.13 shows *taxa*, by region, divided on the basis of the chorological chorotype. It can be seen that the arctic-alpine chorotype (A) displays the highest numbers in all regions of the Alps. It is, moreover, also present, albeit in reduced numbers, in the Apennine regions, such as Abruzzo, and to a still lesser extent in Emilia Romagna, Toscana and Lazio. The subarctic-subalpine chorotype (B) is also well represented, with numbers that are fairly homogeneous, in all the regions of the Alps, in Abruzzo, Emilia Romagna and Toscana.

With the exception of the oceanic-mediterranean chorotype (F), the numbers of which are particularly high in the regions of central and southern Italy (and highest of all in Campania, Sicilia and Sardegna), all the other chorotypes are uniformly represented in all regions of Italy.

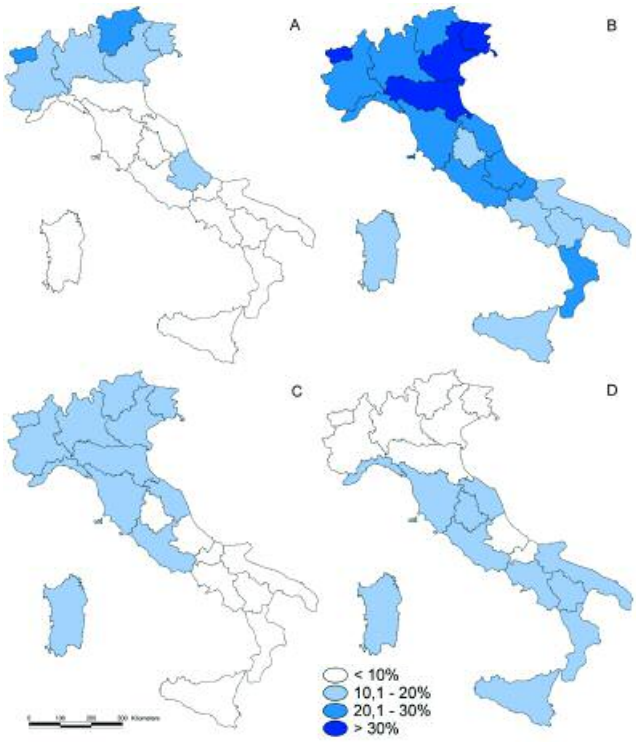

Fig. 4.20 - The main chorological elements in the different Italian regions, divided into frequency classes with a 10% increase: arctic-alpine/sub-arctic-sub-alpine (A); boreal (B); oceanic/sub-oceanic (C); mediterranean/sub-mediterranean (D).

The percentages of the main chorotypes in the various regions are shown in Figure 4.20 (four frequency bands, with a width of 10% have been distinguished). These are the arctic-alpine and subarctic-subalpine (A), the boreale (B), the oceanic-suboceanic (C) and the mediterranean-submediterranean (D).

Considering all those *taxa* which are assignable to the arctic-alpine and subarctic-subalpine chorotypes, it can be seen that the highest numbers occur for the Valle d'Aosta and Trentino-Alto Adige, followed by the the other regions of the Alpine chain. For the majority of the species belonging to these two chorotypes the Alpine chain represents the southern limit of their distribution area in Europe. Some species, however, have pushed further south, to the highest peaks of the Apuane Alps (*Eremonotus myriocarpus*) and of the Apennines – particularly in Abruzzo, where in recent years various arctic-alpine and subacrtic-alpine species have been found, such as *Asterella gracilis*, *Calypogeia suecica*, *Lophozia ascendens*, *Tritomaria scitula*, *Encalypta alpina*, *Pohlia ludwigii*, *Schistidium atrofuscum* and *Seligeria calcarea*.

As far as the boreal chorotype is concerned, maximum numbers occur for the Valle d'Aosta, Friuli-Venezia Giulia, Veneto and Emilia-Romagna. Regarding Molise, it is interesting to note that in the work on the bryological flora of the Mainarde, a mountain chain with several peaks between 1,800 and 2,200 m a.s.l. (CORTINI PEDROTTI & ALEFFI, 1992a), the boreal chorotype was, at 29.4%, the most widely represented after the temperate chorotype. Among the species which are most representative of the boreal chorotype, worth noting are *Porella baueri*, *Scapania calcicola*, *Anomodon longifolius* and *Blindia acuta*.

Fig. 4.21 - *Leucobryum glaucum* is an oceanic species, typical of acid and preferably moist forest soils.

The highest numbers of taxa assignable to the oceanic-suboceanic chorotype are displayed in the northern regions, in particular Trentino-Alto Adige, Veneto, Friuli-Venezia Giulia and Toscana. In Toscana the oceanicity is a consequence of the prevailing south-westerly winds which, striking the mountains of the Toscano-Emiliano Apennines at right-angles, produce heavy rainfall – in excess of 2,500 mm on the highest peaks. This oceanicity is even more marked in the Apuane Alps where, owing to the high rainfall, many microclimates have been created which provide refuge for various euro-oceanic species, such as *Dumortiera hirsuta*, *Harpalejeunea ovata*, *Lejeunea lamacerina*, *Marchesinia mackaii*, *Plagiochila exigua*, *P. killarniensis*. In Umbria, too, a significant penetration of oceanic species has been found, in the woods on the plains surrounding lake Trasimeno and in those in the Gubbio basin (ALEFFI, 1992a, 1992b) (Figure 4.21).

Finally, Figure 4.20 is a map of the different frequency bands of the Mediterranean-sub-Mediterranean chorotype, from which it can be seen that the regions with relatively higher percentages are those towards the

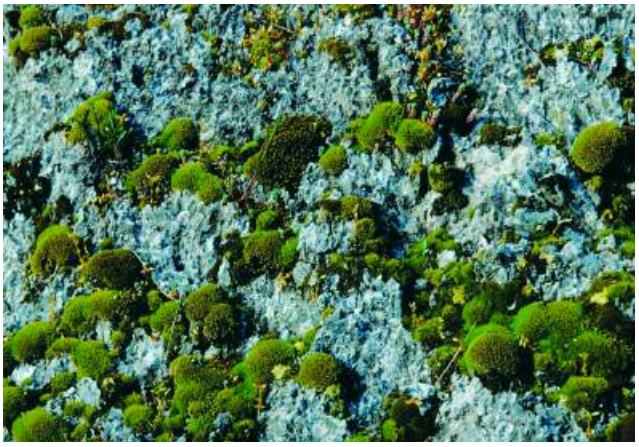

Fig. 4.22 - *Tortula revolvens* is a rare mediterranean species, occurring only on gypsiferous sunny substrates.

south on the Tyrrhenian side (in particular Campania, Sardegna and Sicilia), whereas the regions with relatively lower percentages are those of the north of Italy, together with Abruzzo and Molise (for reasons discussed above regarding the arctic-alpine and boreal chorotypes). The Mediterranean climate type is, in any case, present in some degree throughout the Italian peninsula, as a consequence of its central position within the Mediterranean basin (Figure 4.22). Among the species which are typical of Mediterranean environments, *Petalophyllum ralfsii* deserves to be singled out, because of its unique structure and the fact that it occurs in sandy retrodunal and lagoon environments. This species is very rare and is critically endangered.

BRYOPHYTES AS BIO-INDICATORS

[Michele Aleffi]

The monitoring of atmospheric pollution is commonly performed using instruments that are both sophisticated and expensive, such as automatic electronic monitoring stations. These stations provide precise measurements, in real time, of changes in concentrations of pollutants. However measurements of this type are extremely localised and involve high running costs. It is therefore necessary to look for new instruments that are capable of taking into account the dispersion, the transport and re-depositing of pollutants over very wide areas. Only bio-indicators are capable of providing pointers to the wider biological effects of a specific polluting situation, taking the synergy between various toxic substances into account in a 'natural' way.

Biomonitoring also offers guarantees as regards reliability, because it is possible to use different organisms for different pollutants. Moreover, the information provided by biomonitoring is retrospective, since symptoms can be detected even at a certain spatial and temporal distance from a polluting episode.

The use of mosses as bioindicators offers considerable advantages in the monitoring of trace elements, since they receive the substances essential for their sustenance from the air which surrounds them, making them capable of living in environments which are highly contaminated. In fact, measurements obtained using mosses have been confirmed by measurements obtained using automatic electronic monitoring stations. Despite this, it has to be said that, in order for data acquired by bioindicators to become accepted as valid, all procedures - from sampling to analysis of results - must scrupulously follow norms established within a standardised protocol.

A biomonitoring study was recently carried out in the Monti Sibillini National Park. 22 sampling sites were chosen, mainly in the proximity of populated centres, or of areas where the impact of human activity is high (i.e. those areas most frequented by tourists). The accumulation of trace elements deriving either from human activity, or from that of the earth's crust, were measured using soil samples and specimens of the moss *Hypnum cupressiforme*, which was selected because of its ubiquity throughout most of Europe.

The results of the research on mosses and soils of the Monti Sibillini National Park confirmed that mosses can be successfully employed to measure the redepositing in the soil of persistent contaminants, such as heavy metals.

In addition to *Hypnum cupressiforme,* various other species are capable of providing high levels of bioindication and can therefore be used for environmental biomonitoring. Among these species, *Bryum argenteum* and *Tortula muralis* certainly need pointing out. These two terricolous mosses, which form dense little cushions, are among the species which are most resistant to even high concentrations of pollutants. Because of this tolerance these mosses are used for the monitoring of industrial areas where atmospheric pollution is particularly heavy and for measuring the redeposition in the soil of trace elements. In aquatic environments, *Fontinalis antipyretica* and *Rhynchostegium riparioides* are the two species which are, in the main, used in monitoring studies, by virtue of their ubiquity and their resistance to pollutants.

Nevertheless, we can state that each species displays a different degree of tolerance with respect to pollutants. This permits 'scales of tolerance' to be drawn up and by means of these it is possible to provide an estimate of the degree of pollution in a given area, on the basis of its bryological flora.

Recent studies carried out in urban areas in the Marche and also in Spain, have demonstrated that certain species have differing sensitivities to SO_2. *Orthotrichum diaphanum* and *Tortula papillosa*, two liverwort species, have been shown to have medium tolerance, whereas *Tortula ruralis* is to be considered as tolerant, in that - although it is not particularly favored by SO_2 pollution - it is capable of enduring high concentrations of the substance. On the basis of considerations such as these we may observe that, in floristic terms, the species which occur with the greatest frequency in the urban areas which were studied, are likely to be those which have the highest resistance to pollutants.

Fig. 4.23 - *Thamnobryum alopecurum* grows on moist and dripping rocks in forestal habitats. The deforestation and thinning out of the woods cause the disappearance of this and other species growing in particularly moistened and shaded microclimatic conditions.

Conservation problems

The bryological richness and diversity that can be found in Italy are the result of various geographical and ecological factors: 1) as a consequence of the considerable extension across latitudes of the Italian peninsula, Italian bryological flora is rich in arctico-alpine and boreal, mediterranean and oceanic species, 2) Italy, except for the Pianura Padana, is mostly mountainous and has a great variety of lithological substrates and a multiplicity of geomorphologic features (volcanoes, moraines, peat-bogs, lakes, etc.) and this leads to greater taxonomical diversity in comparison to that found in other Mediterranean countries.

It has now been clearly established that the survival of many species of bryophyte depends on the conservation of their natural habitats. In spite of this, the lack of rigorous measures for the protection of forests and wetlands - the two habitats preferred by bryophytes, owing to their extreme diversity of microclimates and substrates - is resulting in the extinction of many bryophyte species. This is particularly the case regarding saprolignicolous species which colonize decaying tree-trunks and for epiphyllous species. Deforestation, together with routine forestry-management practices such as the removal of old tree-trunks and the planting of alien species, are only the more obvious examples of the way such environments are being destroyed (Figure 4.23).

Atmospheric pollution poses the most serious threat to epiphyte species, especially to those most sensitive to polluting agents; the effect of greatly increased acidity of rainfall and substrates is to considerably diminish the number of epiphyte species.

The second most serious threat to bryophyte species comes from extraction, drainage, forestry and polluting activities in wetlands and bogs. Finally, in the Mediterranean area, bushfires and consequent soil erosion on the one hand, together with high anthropic pressure due to tourism on the other hand, represent constant threats to coastal habitats.

It therefore needs stating again that appropriate and effective protective action needs to be directed not simply towards individual endangered species, but rather towards the conservation of the environments that can guarantee survival of these species. It is towards this objective that the catalogues and the regional and national Red Lists can make a significant contribution, by providing improved knowledge of the biology and ecology of endangered species.

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