Biodiversity Hotspots in the Mediterranean Basin: Setting Global Conservation Priorities

FRÉDÉRIC MÉDAIL* AND PIERRE QUÉZEL

University of Aix-Marseille, F.S.T. St-Jérôme, Institut Méditerranéen d'Ecologie et de Paléoécologie (C.N.R.S.), Case 461, F-13397 Marseille cedex 20, France

Due to the current species extinction crisis, there is an urgent need to identify the most threatened areas of exceptionally high biodiversity and rates of endemism (i.e., "hotspots"; Mittermeier et al. 1998; Myers 1988; Reid 1998). Conservation strategies represent a crucial issue in the mediterranean biome because this area, which represents only 2% of the world's surface, houses 20% of the world's total floristic richness (Médail & Quézel 1997). Myers initially (1988, 1990) defined 14 hotspots in the tropical biome and four in mediterranean bioclimates (southwestern Australia, Cape Region of South Africa, California, and part of Chile). Like the four other mediterranean areas, the Mediterranean Basin is one of the world's major centers for plant diversity, where 10% of the world's higher plants can be found in an area representing only 1.6% of the Earth's surface (Médail & Quézel 1997). The prominent role played by these areas as reservoirs for plant biodiversity has been emphasized by Myers (1990). He hesitated, however, to group the whole Mediterranean Basin into one single hotspot because it covers such a large surface area, and insufficient data were available for certain regions. In this context, Médail and Quézel (1997) performed a global survey of plant richness and endemism to more precisely define hotspots in the Mediterranean Basin; they identified 10 hotspots. Three main approaches, however, have been taken in recent studies performed by international conservation organizations to define priority conservation areas in the Mediterranean Basin.

The first approach, the "megadiversity countries" project (Mittermeier et al. 1997), defined 17 megadiverse countries based primarily on plant endemism, species richness, and political boundaries. The top countries listed were Indonesia, Colombia, Brazil, Australia, Mexico, and Madagascar, but the Mediterranean Basin was completely left out, although, as some authors have recently pointed out (Heywood 1995; Médail & Quézel 1997), several tropical or subtropical countries have lower plant diversity than the Mediterranean Basin. For example, all of tropical Africa has the same plant richness (30,000 taxa) as the circum-Mediterranean region in a surface area four times larger. Furthermore, the Mediterranean Basin possesses 10.8 species/1000 km^2, which is higher than the 3.1 species/1000 km^2 in China, 4.7 in Zaire and in India, and 6.5 in Brazil, but lower than the 40 in Colombia and 90 in Panama (Médail & Quézel 1997).

In the second approach, on the opposite extreme, some recent conservation strategies treat the Mediterranean Basin as a unique hotspot. The Global 200 project, performed by Olson and Dinerstein (1997, 1998), included the whole area in one large ecoregion defined by one rare major habitat type (i.e., Mediterranean shrublands and woodlands). These authors emphasized that "more-detailed, fine-scale analyses are essential to identify important targets within ecoregions." In a recent work, Mittermeier et al. (1998) defined 24 hotspots in which, based on plant endemism, the whole Mediterranean Basin was listed second after tropical Andes. Nevertheless, including all the different parts of the Mediterranean Basin in one unique hotspot seems to oversimplify the situation, even on a global scale. In fact, this area has many highly differentiated biogeographical patterns and land-use practices in space and time within its complex and heterogenous landscapes.

The Mediterranean region constitutes both a refuge area and one that encourages floral exchange and active plant speciation (Quézel 1978, 1985). In the western basin, high-endemism areas are related to the age of the geological platform and relict endemics prevail, whereas in the east, vicariant endemism is high due to the moderate role of glaciations and the presence of ultramafic rocks (Verlaque et al. 1997). Between the northern and southern coasts, human effects have created two different situations (Barbero et al. 1990). The collapse of the

*email f.medail@botmed.u-3mrs.fr

Paper submitted September 22, 1998; revised manuscript accepted June 9, 1999.

agro-sylvo-pastoral system of the past centuries has led to major changes in plant community structure and the extension of woodlands dominated by competitive species. These dynamics have created a homogenization of floral and faunal communities (Covas & Blondel 1998) and a loss of biodiversity. On the other hand, the southern part of the Mediterranean Basin (in particular North Africa) has been subjected to the severe effects of constant increases in population and livestock, which have completely destroyed the soils and caused severe erosion and poor regeneration. Thus, in terms of practical conservation and management, it is impossible to consider the Mediterranean Basin as one single hotspot as suggested by Olson and Dinerstein (1997, 1998) and Mittermeier et al. (1998).

The third approach, the list of 250 centers for plant diversity (CPDs) covering the entire world that has recently been created by the World Wildlife Fund and the World Conservation Union does not include all the Mediterranean Basin hotspots. Davis et al. (1994) identified 8 CPDs (High Atlas in Morocco; Gudar and Javalambra region; Baetic and Sub-Baetic mountains in Spain; mountains of southern and central Greece; Crete; Troodos mountain in Cyprus; southwestern Anatolia and Taurus in Turkey; Levantine uplands between Turkey, Syria, Lebanon, Israel, and Jordan) plus 2 CPDs for the Macaronesian archipelagos (Canary Islands; Madeira), whereas 3 other CPDs (Balkan and Rhodope Mountains; Alps; Pyrenees) are located on the edge of the Mediterranean region but mainly in the temperate biome. This valuable synthesis, however, omits some of the most important hotspots, notably the Tyrrhenian Islands (Balearic Islands, Corsica, Sardinia, and Sicily), the Middle Atlas and Rif mountains (Morocco), and the Maritime-Ligurian Alps (France and Italy), areas well known for their high relictual endemism.

To better assess plant conservation priorities in the Mediterranean Basin, 10 hotspots were defined by Médail and Quézel (1997): the Canary Islands and Madeira, the High and Middle Atlas mountains, the Baetic-Rifan complex, the Maritime and Ligurian Alps, the Tyrrhenian Islands, southern and central Greece, Crete, S. Anatolia and Cyprus, the Syria-Lebanon-Israel area, and the Cyrenaic Mediterranean (Fig. 1). These hotspots cover a small ($<10{,}000$ km^2) or medium-sized (up to 130,000 km^2 for Anatolia) surface area, where plant richness was >2000 species per 15,000 km^2 and where narrow endemism of at least 10% occurred. They represent about 22% (approximately 515,000 km^2) of the total surface of the Mediterranean Basin and include about 5500 narrow endemics (exclusive to hotspots or present in the same biogeographic area surrounding the hotspots, but not throughout the Mediterranean Basin, i.e., 44% of total endemics in this area). Two main centers of biodiversity exist: one in the west, including the Iberian Peninsula (notably with Andalousia) and Morocco (with the Atlas and Rif Mountains), and one in the east, including some parts of Turkey and Greece. The particular nature of the Macaronesian islands (i.e., the high percentage of endemism in Madeira [26%] and in the Canary Islands [38%]), along with their high taxonomic uniqueness, must also be noted in particular because laurel woods have severely regressed.

It could be argued that this selection of Mediterranean Basin hotspots represents only a regional-scale limitation. In fact, because of its paleogeography and historical land-use patterns, the Mediterranean Basin exhibits a fine and complex mosaic of interconnected communities, which

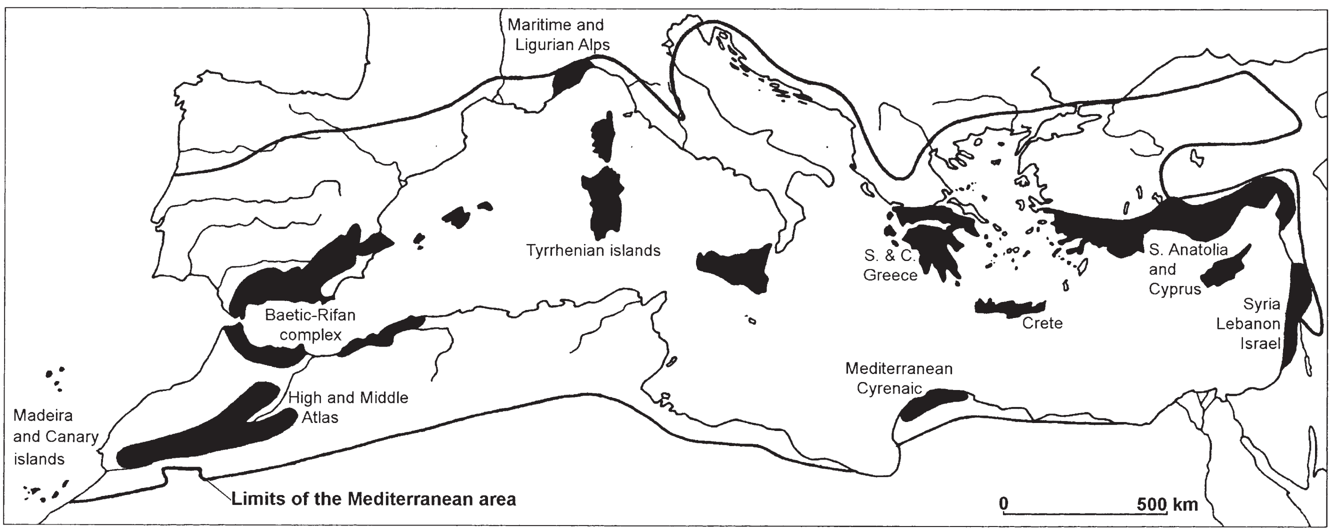

Figure 1. The 10 Mediterranean Basin hotspots based on plant endemism and richness, according to Médail and Quézel (1997, modified).

explains the high alpha and beta diversities (Blondel & Aronson 1995; Covas & Blondel 1998). Nevertheless, this richness is not uniformly distributed, and it is difficult to assess conservation strategies on a global scale in the Mediterranean region. The origin of the high degree of plant richness and endemism in the 10 hot-spots defined on a global level can be traced primarily to paleogeographical and historical factors (Pons & Quézel 1985; Verlaque et al. 1997). More detailed analyses are still necessary to include several well-known groups of animals, particularly amphibians, reptiles, butterflies, and freshwater fishes, which exhibit high endemism according to Covas and Blondel (1998), and to establish a comparative study of plant and faunal richness and endemism in the various hotspots around the Mediterranean Sea.

Generally, the way to define biodiversity hotspots is to identify zones with high plant species richness and endemism (Myers 1988, 1990). These two attributes of plant diversity are commonly used in conservation biology because they reflect the complexity and uniqueness of ecosystems (Caldecott et al. 1996) and because these data are relatively easy to obtain on a global level. But considering only endemic plants in defining a hotspot network leads to oversimplification, even if the distribution of Mediterranean plants is strongly nested within the range of more widespread species (Médail & Verlaque 1997), as opposed to the distribution of British birds reported by Williams et al. (1996). Mittermeier et al. (1998) argue that endemics "are often among the most vulnerable components of any particular community" because of their restricted ranges and are "confined to highly threatened ecosystems [that] will almost certainly be the first hit by extinction episodes." These comments do not reflect the common patterns observed in the Mediterranean Basin, where endemic plants are mainly stress-tolerant species that are adapted perfectly to harsh habitats (rock-crevices, cliffs, screes) and that act as refuges little affected by natural or human disturbances (Médail & Verlaque 1997).

Our focus on the Mediterranean region underlines some discordances among the diverse approaches (hotspots, megadiverse countries, CPDs, the Global 200 project) in determining priority conservation areas. As indicated by Reid (1998) and Ginsberg (1999), these priority-setting exercises are inadequate at a number of scales. Finer-scales hotspots (i.e., regional, biogeographical units) seem more practical and realistic for the Mediterranean region, even if the performed subdivision (due to the high-quality information on plant distribution) of the single big Mediterranean hotspot could entail a "changing of the rules" in the context of broad-scale recognition of hotspots (C.M. Herrera, personal communication). Finally, Mittermeier et al.'s (1998) statement that "there is actually considerable agreement among the different approaches currently in use" seems overly optimistic, although this kind of unified front would be helpful in reacting to increasing threats and proposing a common network of priority conservation areas for political institutions.

Acknowledgments

We thank J. Ginsberg and C. M. Herrera for comments on a previous draft of the manuscript.

Literature Cited

Barbero, M., G. Bonin, R. Loisel, and P. Quézel. 1990. Changes and disturbances of forest ecosystems caused by human activities in the western part of the Mediterranean Basin. Vegetatio **87:**151–173.

Blondel, J., and J. Aronson. 1995. Biodiversity and ecosystem function in the Mediterranean Basin: human and non-human determinants. Pages 43–119 in G. W. Davis and D. M. Richardson, editors. Biodiversity and ecosystem function in Mediterranean-type ecosystems. Ecological studies 109. Springer-Verlag, Berlin.

Caldecott, J. O., M. D. Jenkins, T. H. Johnson, and B. Groombridge. 1996. Priorities for conserving global species richness and endemism. Biodiversity and Conservation **5:**699–727.

Covas, R., and J. Blondel. 1998. Biogeography and history of the Mediterranean bird fauna. Ibis **140:**395–407.

Davis, S. D., V. H. Heywood, and A. C. Hamilton. 1994. Centres of plant diversity. A guide and strategy for their conservation. Volume 1. Europe, Africa, South West Asia and the Middle East. World Wildlife Fund & World Conservation Union, Cambridge, United Kingdom.

Ginsberg, J. 1999. Global conservation priorities. Conservation Biology **13:**5.

Heywood, V. H. 1995. The Mediterranean flora in the context of world biodiversity. Ecologia Mediterranea **20:**11–18.

Médail, F., and P. Quézel. 1997. Hot-spots analysis for conservation of plant biodiversity in the Mediterranean Basin. Annals of the Missouri Botanical Garden **84:**112–127.

Médail, F., and R. Verlaque. 1997. Ecological characteristics and rarity of endemic plants from southeast France and Corsica: implications for biodiversity conservation. Biological Conservation **80:**269–271.

Mittermeier, R. A., P. R. Gil, and C. G. Mittermeier. 1997. Megadiversity. Earth's biologically wealthiest nations. Conservation International, Washington, D.C.

Mittermeier, R. A., N. Myers, J. B. Thomsen, G. A. B. Da Fonseca, and S. Olivieri. 1998. Biodiversity hotspots and major tropical wilderness areas: approaches to setting conservation priorities. Conservation Biology **12:**516–520.

Myers, N. 1988. Threatened biotas: "hot-spots" in tropical forests. The Environmentalist **8:**187–208.

Myers, N. 1990. The biodiversity challenge: expanded hot-spots analysis. The Environmentalist **10:**243–256.

Olson, D. M., and E. Dinerstein. 1997. The Global 200: a representation approach to conserving Earth's distinctive ecoregions. World Wildlife Fund, Washington, D.C.

Olson, D. M., and E. Dinerstein. 1998. The Global 200: a representation approach to conserving the Earth's most biologically valuable ecoregions. Conservation Biology **12:**502–515.

Pons, A., and P. Quézel. 1985. The history of the flora and vegetation and past and present human disturbance in the Mediterranean region. Pages 25–43 in C. Gomez-Campo, editor. Plant conservation in the Mediterranean area. Geobotany 7. Dr. W. Junk, Dordrecht, The Netherlands.

Quézel, P. 1978. Analysis of the flora of the Mediterranean and Saharan Africa. Annals of the Missouri Botanical Garden **65:**479–534.

Quézel, P. 1985. Definition of the Mediterranean region and the origin of its flora. Pages 9–24 in C. Gomez-Campo, editor. Plant conservation in the Mediterranean area. Geobotany 7. Dr. W. Junk, Dordrecht, The Netherlands.

Reid, W. V. 1998. Biodiversity hotspots. Trends in Ecology and Evolution **13:** 275–280.

Verlaque, R., F. Médail, P. Quézel, and J. F. Babinot. 1997. Endémisme végétal et paléogéographie dans le bassin méditerranéen. Geobios, Mémoire spécial **21:**159–166.

Williams, P., D. Gibbons, C. Margules, A. Rebelo, C. Humphries, and R. Pressey. 1996. A comparison of richness hotspots, rarity hotspots, and complementary areas for conserving diversity of British birds. Conservation Biology **10:**155–174.