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Plant species-area relationships in grasslands and woodlands of the Mediterranean Basin: Consequences for the size of reserves

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SUMMARY – Any method for identifying priority conservation areas should take into account the effect of the surface area on species richness. We examined the importance of the plant species-area relationship in a set of 79 areas with a Mediterranean-type climate of the southwestern Mediterranean Basin. The results confirm that the plant species-area curve for Mediterranean grasslands and woodlands in this region fits a power function model. Examination of species/area ratios for these areas suggests also that it is better to have several reserves of medium size (< 100,000 ha) than only one large reserve to support the highest number of plant species at the least cost of protection.

Keywords: Mediterranean Basin, species-area relationships, power model, reserve size.

RESUME – *"Les relations espèces-zones dans les pâturages et les zones boisées du Bassin Méditerranéen : Conséquences pour la taille des réserves". Toute méthode visant à identifier les zones prioritaires de conservation devrait donner de l'importance à l'effet de la superficie sur la richesse des espèces. Nous examinons l'importance de la relation espèces végétales-superficie parmi un groupe de 79 zones à climat méditerranéen au sud-ouest du Bassin Méditerranéen. Les résultats confirment que la courbe espèces-superficie pour les patûrages et les bois dans cette région s'ajuste à un modèle de fonction potentielle. L'analyse de la relation espèces-superficie suggère aussi qu'il est préférable d'avoir plusieurs réserves d'une grandeur moyenne (< 100 000 ha) plutôt qu'une grande réserve, pour maintenir le plus grand nombre d'espèces végétales à un moindre coût de protection.*

Mots-clés : *Bassin Méditerranéen, relation espèces-zone, modèle potentiel, réserve.*

Introduction

From a bio-geographical point of view, the circum-Mediterranean area is a well-defined region (Daget, 1977), showing a remarkable biodiversity (Médail and Quézel, 1997; Myers *et al*., 2000), since almost 10% of the world's vascular plants are located in a mere 1.4% of the Earth's land surface (Table 1). However, species richness (hereafter biodiversity) is not homogeneously distributed throughout the Mediterranean Basin. Médail and Quézel (1997) defined 10 areas of maximum variety of species to better assess plant conservation priorities. The south of the Iberian Peninsula and the north of Morocco, including the Baetic-Riftan complex, are unquestionably one of the main centres of biodiversity in the Mediterranean Basin.

Table 1. Floristic richness of the Mediterranean Basin. Documentation of plant species can be found in Médial and Quézel (1997) and Myers *et al*. (2000)

Mediterranean Basin				
Original extent of primary vegetation (km^2)	Remaining primary vegetation (km^2) (% of original extent)	Area protected (km^2) (% hotspot)	Approximate number of plant species	Endemic plants (% of total)
2,085,292	98,009 (4.7)	42,123 (43.0)	25,000	13,000 (52.2)

Conservation planning currently lacks methods for determining the optimum size distribution of reserves required. The most typical example is the problem of choosing between a large reserve and several small ones (Oertli *et al.*, 2002). In this field, certain empirical evidence has provided different explanations when analysing the species-area relationships in Mediterranean-climate ecosystems (Keeley and Fotheringham, 2003), since the rule that the number of species increases with an increase in area is one of the most robust laws in ecology (Ostling *et al*., 2003). Two models have been widely applied to describe the effect of area (A) on species richness (S) (see Connor and McCoy, 1979; Buys *et al*., 1994), the power model, usually presented as the log transformation of both variables, where c and z are the parameters estimated by linear regression:

$$\log S = \log c + z \log A$$

and the exponential model, expressed as the semi-log equation:

$$S = c + z \log A$$

However, these methods do not provide specific guidance on the reserve size required to maintain the maximum biodiversity. Moreover, there are very few studies carried out on species-area relationships in the southwestern part of the Mediterranean Basin. We examined the importance of the plant species-area relationship among a set of 79 Mediterranean areas of the southwestern Mediterranean Basin, with the purpose of finding the optimum reserve size. Thus, it will be possible to support the highest number of plant species at the least cost of protection, together with a satisfactory planning of Mediterranean reserves.

Although we recognised that the creation and design of protected areas should not be exclusively based on criteria of biodiversity, it is clear that these reserves play an important role in preserving biodiversity. In this paper, we determine plant species-area relationships because they are the basis on which the diversity of other taxonomic groups is founded.

Material and methods

In the Mediterranean Basin, the Ibero-Moroccan region has the greatest variety of plant species, both general and endemic, followed by the eastern part that encompasses Turkey and Greece (Médail and Quézel, 1997). Thus, we considered a set of 79 Mediterranean areas of Portugal, Spain, Morocco and France where floristic data are available (Fig. 1). Together they cover 46,987.53 km^2, an area larger than Denmark or the Netherlands, and represent satisfactorily the main plant formations of the Mediterranean-type climate.

Fig. 1. The 79 Mediterranean areas studied where floristic data are available.

Naturally, in the southwestern part of the Mediterranean Basin, there are numerous sectors that satisfy these criteria, although they are sometimes difficult to define due to insufficient floristic knowledge for specific zones.

We tested several species-area relationship models, including power (widely accepted) and exponential functions (which has also been used by botanists). The magnitude of the adjusted R^2 is a reasonable means of comparing these models (Connor *et al*., 1983). We also analyzed the values of species/area ratios per km^2 of these areas studied, since it provides an evaluation that is independent of surface area.

Results and discussion

Adjusted R^2 value comparisons show that the power function model was the most convenient one for all of these Mediterranean-type climate areas (Fig. 2). The species-area curve parameters were calculated based on the number of species within each area size (Table 2). Nevertheless, the best fit to the power model or exponential model should not be directly linked to any biological functionality of species-area relationships (Connor and McCoy, 1979).

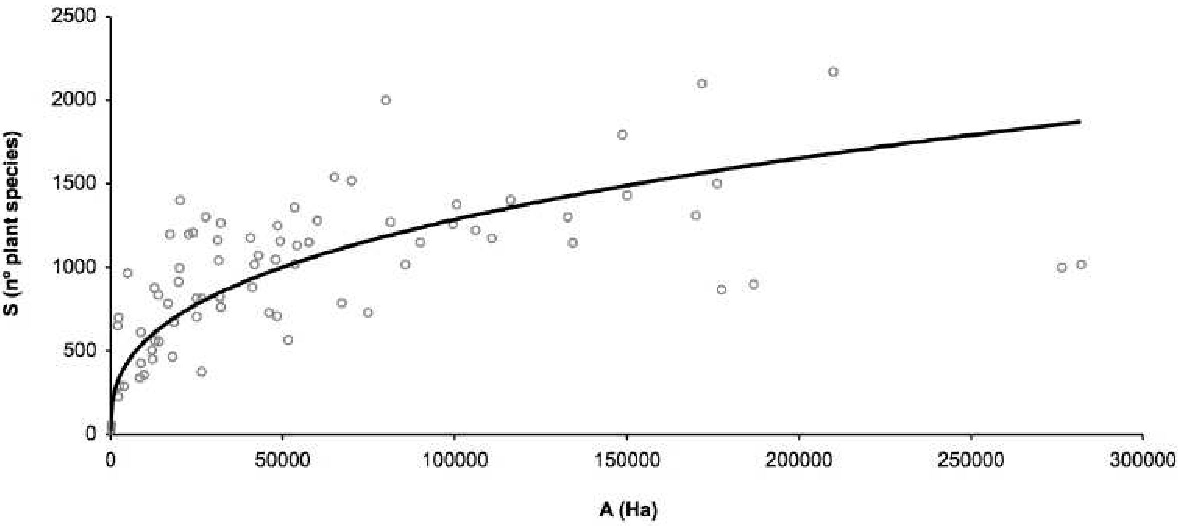

Fig. 2. Plant species-area power function curve for different sites in SW Mediterranean Basin.

Table 2. Comparison of species-area models across Mediterranean type areas, where log *c* describes its intercept and *z* measures the slope or the rate of increase

Nb. of sites	Semi-log	Log-log	Equation	log *c*	*z*
	Adj. R^2	Adj. R^2			
79	0.502	0.809	$\log S = 1.300 + 0.362 \log A$	1.300	0.362

Comparing the species/area ratios for our sites, we also found a better fit to the power model, and it is consistent with the patterns evident in Fig. 3. At the community scale of 1 km^2 for grasslands and woodlands in the southwestern Mediterranean Basin, areas with the highest plant diversity are not necessarily the largest ones, since some areas have their species concentrated in exceptionally small surfaces. An analysis of Fig. 3 of a great variety of Mediterranean-type climate ecosystems suggests that it is better to have several reserves of medium size (< 100,000 Ha) to maximize species/area ratio than a large one.

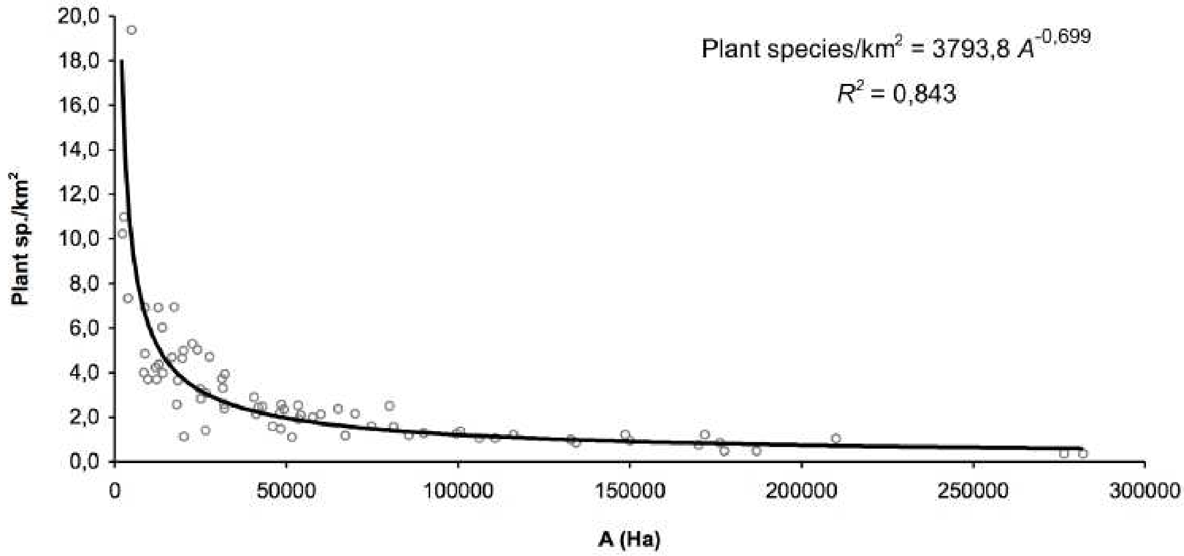

Fig. 3. Plant species/area ratios per km^2 curve for all Mediterranean areas studies.

Conclusions

We have tested several species-area relationship models among a set of 79 areas in the southwestern Mediterranean Basin. Most grasslands and woodlands have plant species-area curves that invariably fit the power function model. We have also analyzed the values of species/area ratios per km^2 of these areas. This indicates the optimum size (< 100,000 Ha) to support the highest number of plant species at the least cost of protection. Because the species-area relationship is a key pattern in ecology, our findings can be applied to identify the more important natural sites and to plan the type of action to be taken. Indeed, much remains to be known and studied in this hotspot, where there is so much biodiversity at stake.

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