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Diversity and conservation of terrestrial vertebrates in mediterranean Chile

Diversidad y conservación de los vertebrados terrestres en Chile mediterráneo

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ABSTRACT

Species diversity, endemism and degree of threat of the terrestrial vertebrates of mediterranean Chile is reviewed. Mediterranean ecosystems cover 16% of the territory but harbor over 50% of Chile´s vertebrate species, 50% of Chilean endemics and, 50% of the endangered species. These attributes render the mediterranean region of Chile a "hot-spot" in terms of vertebrate taxa. Habitat destruction is a major threat to species survival. Few protected areas, generally of small size, are available to protect the vertebrate fauna. Taxonomic coverage of these parks is incomplete and some are smaller than required to sustain viable populations of mammals. The use of the semi-natural matrix surrounding parks is needed to achieve the conservation of this significant biota.

Key words: biodiversity, endemism, hot-spots, protected areas.

RESUMEN

En esta contribución reviso la diversidad de especies, el endemismo y el grado de amenaza de la fauna de vertebrados terrestres de Chile mediterráneo. Los ecosistemas mediterráneos cubren un 16% de la superficie continental de Chile pero albergan más del 50% de las especies de vertebrados, el 50% de las especies chilenas endémicas y el 50% de las especies amenazadas. Estos atributos confieren el carácter de "punto caliente" ("hot-spot") a la región en términos de los vertebrados. La destrucción de habitat es la mayor amenaza para la sobrevivencia de los vertebrados. Sin embargo, existen pocos y generalmente pequeños, parques y reservas para proteger esta fauna. No todas las especies están presentes en algún área protegida, algunas de las cuales son más pequeñas que lo necesario para sostener poblaciones viables de mamíferos. El uso de la matriz semi-natural que rodea los parques es necesaria para asegurar la conservación de los vertebrados terrestres de Chile mediterráneo.

Palabras clave: áreas protegidas, biodiversidad, endemismos, puntos-calientes ("hot-spots").

INTRODUCTION

Mediterrean ecosystems are considered "hot-spots". Hot-spots are areas harboring high concentration of endemic species which experience accelerated rates of habitat destruction (Myers 1990). Mediterranean ecosystems as a whole are rich in plant species, with almost 20% of the world plant species, despite the fact that these ecosystems cover only 5% of the Earth´s surface (Cowling et al. 1996). This biological richness is threatened by an accelerating rate of extinction triggered by anthropogenic landscape changes (Greuter 1995). The combination of biotic richness and high extinction renders mediterranean ecosystems in focal areas for protection along with the highly diversified tropical forests (Myers 1990).

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The increase of human impacts worldwide renders the selection of protected areas mandatory where there is high biodiversity that is also most endangered. If the diversity of several taxa is similarly distributed in space, such congruent distributions will render conservation activities more cost-effective (Prendergast et al. 1993, Williams et al. 1996). The recognition of mediterranean ecosystems as "hot-spots", and the delimitation of "hot-spots" within mediterranean ecosystems have been based on the examination of plant biodiversity (Myers 1990, Medail & Quezel 1997). Whether other taxa have congruent patterns of richness and endangerment is yet to be established. Here, I review whether the mediterranean ecosystems of Chile is also rich regarding thee diversity of terrestrial vertebrates.

In Chile, mediterranean ecosystems cover roughly 16% of the country, from the northern limit of the IV Region (app. 30°) to the southern limit of the VII Region (app. 36° S) (di Castri 1973). To be considered a "hot-spot", this region should harbor a fraction of the biota larger than expected by its area alone. Therefore, I first analize what fraction of the species richness, endemisms and endangered species are present in mediterranean Chile compared to country totals. Then, I briefly analize threats to vertebrate survival and the protection given by national parks and other protected areas.

Diversity of terrestrial vertebrates

The terrestrial vertebrates of Chile comprises 550 species, freshwater fishes and oceanic birds excluded (Table 1). Birds are the most speciose taxon with over 320 species (59%), distantly followed by mammals with 95 species (17%) and reptiles with 93 species (17%), and amphibians accounting for 40 species (7%; Araya & Bernal 1995, Contreras & Yáñez 1995,

TABLE 1

Species richness, endemism and threatened terrestrial vertebrates of Chile. Figures are number of species of each taxon in Chile and the number and percentage of them occurring in the mediterranean region. For endemics, figures are the number and percentage of endemic species in relation to the total species number in Chile, and the number and percentage of endemics species occurring in the mediterranean region in relation to the endemic species of Chile (see Simonetti et al. 1995 and references therein for sources). For threatened species, figures are the number and percentage of threatened species regarding the total species number in Chile, the number of threatened species occurring in the mediterranean region, and the percentage of them regarding both the total threatened species of Chile (%Ch) and the number of species inhabiting the region (%M) (source: Glade 1988)

Riqueza de especies, endemismo y especies amenazadas de vertebrados terrestres de Chile. Los valores son el número de especies de cada taxón en Chile y el número y porcentaje de especies que ocurre en la región mediterránea. Para las especies endémicas, los valores son el número y porcentaje de especies endémicas sobre el total de especies en Chile y el número y porcentaje de especies endémicas respecto del total de endémicas del país (véase Simonetti et al. 1995 y referencias citadas para las fuentes). Para las especies amenazadas, los valores son el número y porcentaje de especies amenazadas respecto del total de especies de Chile, el número de especies amenazadas que ocurre en la región mediterránea y el porcentaje de ellas respecto el total de especies amenazadas en Chile (%Ch) y el número de especies que habita la region (%M) (fuente: Glade 1988)

	Species richness			Endemism				Threatened				
	Chile	mediterranean		Chile		mediterranean		Chile		mediterranean		
axon	n	n	%	n	%	n	%	n	%	n	%Ch	%M
amphibians	40	12	30	24	60	6	25	31	78	11	35	92
reptiles	93	38	41	56	60	31	55	45	48	20	44	53
mammals	95	37	39	15	16	7	47	47	49	24	51	65
birds	322	200	62	7	2	7	100	49	15	31	63	16
total	550	287	52	102	19	51	50	172	31	86	50	30

Formas 1995, Veloso et al. 1995, and references therein).

The mediterranean region, as delimited above, holds over 50% of this biota, particularly birds (Table 1). In all taxa, the proportion of the fauna present in the mediterranean region is significantly higher than the proportion expected based on its size alone (i.e., 16%; Wilcoxon: $Z > 2.4$, $P < 0.008$ in all four cases). Expressed as species density, continental Chile supports 0.07 species/100 km^2 while the mediterranean region holds 0.13 species/100 km^2, a 1.9 fold difference. That is, the mediterranean region is comparatively a species-rich region within Chile.

At the species level, 102 of the 550 terrestrial vertebrates are endemic to Chile. Of these, amphibians and reptiles depict the highest endemism, with 60% of their biota endemic to Chile. Mammals and birds show low levels of endemism (Table 1; Araya & Bernal 1995, Contreras & Yáñez 1995, Formas 1995, Veloso et al. 1995, and references therein). Half of the species endemic to Chile are present in the mediterranean region, specially birds of which all Chilean endemics occur here (Table 1). With the exception of amphibians, the proportion of endemic species occurring in the mediterranean region is significantly higher than the proportion expected based on its size alone ($Z \geq 2.3$, $P \leq 0.01$ for reptiles, mammals and birds, and $Z = 1.2$, $P = 0.1$ for amphibians). Overall though, the proportion of terrestrial endemic species is higher than the proportion expected based on its size ($Z = 9.5$, $P << 0.001$). Of the 102 species endemic to Chile present in the mediterranean region, 21 (20.6%) are restricted to it: three amphibians, 16 reptiles, two mammals but no bird species. That is, the mediterranean as defined here, holds a large fraction of the terrestrial biota of Chile, particularly endemic species, satisfying one of the criteria to be recognized a "hot-spot".

Status of terrestrial vertebrates

Over 170 species, one-third of the terrestrial vertebrates of Chile, are of some conservation concern (Table 1; from Glade 1988). On absolute terms, birds comprise the taxon with more threatened species (49) accounting for 28.5% of Chilean threatened species, but closely followed by mammals (47 species, 27.3%) and reptiles (45 species, 26.2%), while amphibians account for 18.0% (31 species) of the threatened vertebrates (Table 1). However, compared to the diversity of each taxon, amphibians is the most affected taxa nation-wide, as 78% of its species are of conservation concern. Similarly, almost 50% of Chilean reptiles and mammals are threatened while only 15% of the avifauna is so considered (Table 1)

As with species richness, half of the endangered Chilean vertebrates inhabit the mediterranean region (Table 1). Over 30% of the threatened amphibians occur in the region, like 44% of threatened reptiles, 51% of mammals and 63% of the threatened birds. That is, mediterreanean Chile holds a significant fraction of the Chilean threatened biota (Table 1). This fauna represents 30% of the species pool of mediterranean Chile. While threatened birds represent 16% of the avifauna occurring in the mediterranean region, the 11 threatened amphibian species imply that 92% of the frog fauna of mediterranean Chile faces some conservation problem. Similarly, over 50% of the reptile and mammal species of the region face some conservation problems (Table 1).

Threatened amphibians and reptiles in mediterranean Chile are largely endemic species. Six out of 11 threatened amphibians (55%) and 13 out of 20 threatened reptiles (65%) are endemics. Among mammals and birds the proportion of endangered endemic species is lower, with five out of 24 mammals (21%) and one out of 31 threatened bird species (3%) regarded as threatened. That is, a unique herpetozoan fauna might be lost due to anthropogenic activities.

The vertebrate fauna of Chile is threatened by different factors, with habitat disruption and illegal hunting being especially prominent factors mediterranean Chile (Miller 1980, Miller et al. 1983, Jaksic & Jiménez 1986, Rottmann & López-Calleja

1992). Among mammals in the mediterranean region, 85% are threatened by hunting and 69% habitat destruction, figures 1.7 and 1.4 times larger than the proportion of species menaced by these factors in the whole country (50% and 46%, respectively; Miller et al. 1993). Habitat reduction and hunting affects more likely large bodied species, as they require more habitat to sustain populations and are more rewarding targets for hunters. In fact, mammal species weighting one kg or more represent 16% of the Chilean fauna, but they account for 33% of the threatened species in Chile and 43% of them in mediterranean Chile (data updated from Mella 1994). Large bodied mammals are largely carnivores, whose functional or local extinction could trigger changes among their prey fauna (Simonetti & Mella 1997).

Despite the significant fraction of the vertebrate biota menaced by human activities, the importance of the threatened fauna as an environmental problem in mediterranean Chile is perceived as a minor problem by Chileans. Ranked from 0 (irrelevant) to 5 (maximum importance), the threatened fauna scores mean ± SE = 2.8 ± 0.8 (low importance) among a broad group of environmentalists that ranked environmental problems in Chile (data from Hajek et al. 1990). This figure is lower than the relevance given to threatened fauna elsewhere in Chile (3.5 ± 0.5; Hajek et al. 1990, Simonetti 1994). Therefore, conservation strategies to be implemented to protect the vertebrate fauna of mediterranean Chile might lack the necessary social support (Simonetti 1994).

The conservation of the fauna

The conservation of the Chilean depends largely on the National System of Protected Areas (known as SNASPE), which includes national parks and reserves. As of December 1996, the SNASPE comprises 92 units covering 14,433,892 ha, roughly 19% of the continental surface of the country. However, this coverage is unevenly distributed over the different ecological regions of Chile (e.g., Mardones 1995). Only 134,643 ha are protected in the mediterranean region, representing just 0.9% of the total protected area in Chile or 0.2% of the continental surface of Chile (Mardones 1995, Muñoz et al. 1996). Furthermore, the size of protected areas is significantly smaller compared to parks and reserves elsewhere in continental Chile. On average, protected areas in mediterranean Chile cover 6,120.1 ± 1,803.9 ha (mean ± standard error), while they cover 205,882.6 ± 66,876.9 ha elsewhere in Chile (Wilcoxon $Z = 4.3$, $P << 0.001$, $n = 90$; data from Muñoz et al. 1996). That is, the coverage of the SNASPE in the mediterranean region is scant and scattered in small parks and reserves.

Ideally, the SNASPE should habor all vertebrate species of conservation concern. This goal seems unfulfiled in mediterranean Chile, and could be taxon dependent. For mammals, no single conservation unit contains the complete set of large mammal species inhabiting the mediterranean region as a whole or any given administrative region of Chile located within it (Mella 1994). Sixteen mammal species larger than one kg are present in the mediterranean region. Three of them, *Zaedyus pichiy* (Desmarest, 1804), *Oreailurus jacobita* Cornalia, 1865, and *Lontra provocax* (Thomas, 1908) have not been recorded in any protected area of the region, despite being of conservation concern: *O. jacobita* is classified as Rare, and *L. provocax* as Endangered (Glade 1988). Two foxes (*Pseudalopex culpaeus* (Molina, 1782) and *P. griseus* (Gray, 1837)) are the most ubiquitous species, but even them occupy only half the number of conservation units available at the mediterranean region (Mella 1994; Table 2). That is, even the complete set of protected areas does not cover the complete mammalian assemblage. For reptiles however, the scenario could be somewhat different. For instance, 15 out the 18 reptiles inhabiting the Metropolitan Region (located at the center of the mediterranean region) are present within the Rio Clarillo National Reserve, which covers only 10,185 ha at the outskirt of the Andes. Paradoxically, an endangered species, *Liolaemus gravenhorsti* (Gray, 1845) does

not inhabits the Reserve (Díaz & Simonetti 1996). That is, several species of conservation concern survive outside the SNASPE.

To achieve an effective conservation of vertebrate biodiversity, parks and reserves should offer areas large enough to ensure that populations will attain viable sizes within their boundaries. Nine parks and reserves in the mediterranean region are smaller that the area required to sustain viable populations of *Pudu puda* (Molina, 1872), *Puma concolor* (Linnaeus, 1771), *P. culpaeus* and *P. griseus* (Table 2). For instance, the El Morado National Monument offers less area than required to sustain a viable population of 500 individuals of *P. culpaeus*. Similarly, Fray Jorge National Park and Lago Peñuelas National Reserve are insufficiently large to support such populations of *P. culpaeus* and *P. griseus*. By the same token, La Campana National Park, Río Clarillo National Reserve and Las Chinchillas appear smaller than required to support *P. culpaeus*, *P. griseus* and *P. concolor*, while Los Ruiles National Reserve seems smaller than the area required to support *P. griseus* and *P. puda*, Altos de Lircay National Reserve for *P. culpaeus* and *P. concolor*, and Radal Siete Tazas National Reserve for *P. culpaeus*, *P. concolor* and *P. puda* (Mella 1994). That is, protected populations could become extinct within parks due to stochastic processes associated with small population size. Clearly, the SNASPE is not sufficient itself to ensure the survival of the vertebrates of mediterranean Chile due to partial coverage of species and inadequate amount of land protected, menacing the conservation of the high richness and endemisms of the biota (Simonetti & Mella 1997).

The lack of protected areas is perceived by Chileans as an environmental problem (Espinoza et al. 1994) although only a minor one. Ranked from 0 (irrelevant) to 5 (maximum importance), the lack or inadequacy of the SNASPE in non-medite-

TABLE 2

Conservation of large mammals (> 1 kg) in parks and reserves of mediterranean Chile. Figures are the number of parks and reserves where a species has been recorded, the percentage of parks inhabited regarding the total parks available (n = 19), the area (km^2) required to sustain a viable population of 500 individuals and the number of parks that have such an area. n.d. = no available information (sources: Mella 1994, Simonetti & Mella 1997)

Conservación de mamíferos grandes (> 1 kg) en parques y reservas de Chile mediterráneo. Los valores son el número de parques y reservas donde se ha registrado la especie, el porcentaje de parques habitados respecto del total disponible (n = 19), el área (km^2) requerida para sostener una población viable de 500 individuos y el número de parques que contienen tal superficie. n.d.= sin información disponible (fuentes: Mella 1994, Simonetti & Mella 1997)

Species	Parks & reserves Number	%	Area	Parks with area
Lontra provocax (Thomas, 1908)	0		n.d.	
Orealirus jacobita (Cornalia, 1865)	0		n.d.	
Zaedyus pichiy (Desmarest, 1804)	0		n.d.	
Hippocamelus bisulcus (Molina, 1782)	1	5	278-25,000	1
Lama guanicoe (Müller, 1776)	1	5	33-1,000	1
Pudu puda (Molina, 1782)	2	11	79-128	0
Oncifelis guigna (Molina, 1782)	2	11	n.d.	
Myocastor coypus (Molina, 1782)	2	11	n.d.	
Lagidium viscacia (Molina, 1782)	4	21	n.d.	
Oncifelis colocolo (Molina, 1782)	4	21	n.d.	
Conepatus chinga (Molina, 1782)	5	26	n.d.	
Puma concolor (Linnaeus, 1771)	5	26	12,500-25,000	0
Galictis cuja (Molina, 1782)	9	47	n.d.	
Pseudalopex culpaeus (Molina, 1782)	10	53	357-5,000	2
Pseudalopex griseus (Gray, 1837)	11	58	114-1,667	5

rranean Chile scores 1.3 ± 0.6 (minimum importance) among Chilean environmentalists. This figure is almost twice as high in the mediterranean region, where it averages 2.4 ± 1.0, but still considered of low importance (data from Espinoza et al. 1994). Such a perception contrasts with the low representation of the mediterranean region in the SNASPE , the low suitability of the current conservation and the status of the regional vertebrates, with a third of its species threatened (Table 1).

DISCUSSION

The mediterranean region of Chile (as defined here) despite covering 16% of the Chilean territory holds a disproportionally larger number of terrestrial vertebrate species, including half the endemic fauna of the country. This fauna is suffering increasing threats due to habitat destruction and hunting, with half the threatened species of Chile inhabiting the region. The combination of high species richness particularly of endemics, and threats satisfy the conditions to be considered a "hotspot" (cf. Myers 1990). At this coarse level, there is congruence between the distribution of both vascular plant richness (Arroyo et al. 1995) and terrestrial vertebrates, rendering the mediterranean region a prime target for conservation efforts. However, the conservation of this biotic wealth is a challenging task.

The mediterranean region has been inhabited by human populations at least since 11,000 BP. Landscape transformation started with the arrival of the first Amerindian populations and has continued up to the present (Simonetti & Cornejo 1990). A conspicuous effect has been a reduction of the vegetation cover and disruption of the vegetation structure, altering habitat availability for vertebrates. Habitat encroachment coupled with hunting pressure had detrimental effects upon vertebrates during prehistoric times, reducing the diversity and abundance of mammalian species, even prior to more intense land-use practices adopted since the Spanish conquest (Miller 1980, Simonetti & Cornejo 1990, Simonetti & Saavedra 1998). Currently, the mediterranean region holds 58.7% of the human population, with an average of of 0.66 persons/ha, figure 3.6 times larger than the national average[1] .Concomitant with this large population, the landscape has been extensively modified by human activities (Fuentes 1990), to the point were almost half the vertebrate biota of the region is threatened.

The typical approach of protecting species in parks and reserves, albeit necessary, seems insufficient. Conservation units do not contain the whole set of threatened species nor these units provide areas large enough to sustain viable populations of some large bodied species. That is, despite deployed conservation efforts, some extinctions might be expected even within protected areas. A significant increase of the coverage of the SNASPE in the mediterranean region, albeit desirable to solve these problems, is unlikely to occur. The scant number of currently existing small units resulted from establishing parks and reserves in the few public lands available and the scarce number of areas with representative samples of ecosystems depicting low degrees of alteration, along with the past tendency to protect forested landscapes of southern Chile (Ormazábal 1993). Given the high number of people inhabiting the region, no large land tracts are available and the acquisition of lands for conservation is not a governmental priority. If any, the SNASPE might increase through small units (Ormazábal 1993). A positive signal in this regard is that six new sites been indeed added since 1993. However, four of them are small: a 50 ha increase in the area of the existing Los Ruiles Reserve, bringing it to 95 ha, and three other new reserves of 147, 417 and 520 ha, respectively. The new larger units cover 5,148 and 12,163 ha, respectively (Muñoz et al. 1996). Only the two last units are large enough to sustain viable populations of large mammals (Simonetti & Mella 1997).

1 Censo de Población y Vivienda 1992.

Besides adding new lands to the SNASPE, public-private cooperation appears as an alternative. Private lands surrounding parks and reserves could provide the much needed surface to ensure the survival of wild vertebrates. Currently, a large number of wild species survive in lands devoted to productive uses or, in general, to uses other than conservation (e.g., Western 1989). The reliance upon these lands will require social support, particularly from land-owners who should directly benefit from the presence of wild species on their lands, while adapting their land use patterns to render viable the survival of some wild species (e.g., Metzger 1983, Harris 1984, Simonetti 1998), much alike in the Biosphere reserve concept (Halftter 1980).

The development of such initiatives might by hampered the low social perception of the problems faced by the SNASPE and the conservation status of the biota as well (Filp et al. 1983, Fuentes et al. 1984, Simonetti 1994). However, this problem could be overcomed if tangible benefits to the Chilean society are indeed derived or make evident from the presence of wild species in private lands (Wells & Brandon 1992). As Hales (1989: 143) stated: "... the key element [...] is not answering whether integration of parks and surrounding areas is important, but how should occur, and to what degree". The conservation of the terrestrial vertebrates of the mediterranean region of Chile depends upon a correct answer to this pressing question.

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LITERATURE CITED

ARAYA B & M BERNAL (1995) Aves. In: Simonetti JA, MTK Arroyo, AE Spotorno & E Lozada (eds) Diversidad biológica de Chile: 350-360. Conicyt, Santiago.

ARROYO MTK, L CAVIERES, C MARTICOREN & M MUÑOZ-SCHICK (1995) Convergence in the Mediterranean floras in central Chile and California: insights from comparativa biogeography. In: Arroyo MTK, PH Zedler & MD Fox (eds) Ecology and biogeography of Mediterranean ecosystems in Chile, California, and Australia: 43-88. Springer-Verlag, New York.

CONTRERAS LC & JL YAÑEZ (1995) Mamíferos. In: Simonetti JA, MTK Arroyo, AE Spotorno & E Lozada (eds) Diversidad biológica de Chile: 336-349. Conicyt, Santiago.

COWLING RM, PW RUNDEL, BB LAMONT, MK ARROYO & M ARIANOUTSOU (1996) Plant diversity in mediterranean-climate regions. Trends in Ecology and Evolution 11: 362-366.

DI CASTRI F (1973) Climatographical comparison between Chile and the western coast of North America. In: di Castri F & HA Mooney (eds) Mediterranean-type ecosystems: origins and structure: 21-36. Springer-Verlag, Berlin.

DIAZ I & JA SIMONETTI (1996) Vertebrados en áreas silvestres protegidas: los reptiles de la Reserva Nacional Río Clarillo. Vida Silvestre Neotropical 5: 140-142

ESPINOZA G, P GROSS & E HAJEK (1994) Percepción de los problemas ambientales en las regiones de Chile. Comisión Nacional del Medio Ambiente, Santiago. 647 pp.

FILP J, E FUENTES; S DONOSO & S MARTINIC (1983) Environmental perception of mountain ecosystems in central Chile: an exploratory study. Human Ecology 11: 345-351.

FORMAS JR (1995) Anfibios. In: Simonetti JA, MTK Arroyo, AE Spotorno & E Lozada (eds) Diversidad biológica de Chile: 314-325. Conicyt, Santiago.

FUENTES ER (1990) Landscape change in mediterranean-type ecosystem habitats of Chile: patterns and processes. In: Zonneveld IS & RTT Forman (eds) Changing landscapes: an ecological perspective: 165-190. Springer-Verlag, New York.

FUENTES ER, GA ESPINOSA & I FUENZALIDA (1984) Cambios vegetacionales recientes y percepción ambiental: el caso de Santiago de Chile. Revista de Geografía Norte Grande (Chile) 11: 45-53.

GLADE A, ed (1988) Red list of Chilean terrestrial vertebrates. Corporación Nacional Forestal, Santiago. 67 pp.

GREUTER W(1995) Extinctions in Mediterranean areas. In: Lawton JH & RM May (eds) Extinction rates: 88-97. Oxford University Press, New York.

HAJEK ER, P GROSS & GA ESPINOZA (1990) Problemas ambientales de Chile. 2 vols., AID & Pontificia Universidad Católica de Chile, Santiago.

HALES D (1989) Changing concepts of national parks. In: Western D & M Pearl (eds) Conservation for the twenty-first century: 139-144. Oxford University Press, New York.

HALFFTER GH (1980) Biosphere reserves and national parks: complementary systems of natural protection. Impact of Science on Society 30: 269-277.

HARRIS LD (1984) The fragmented forest: island biogeography and the preservation of biotic diversity. University of Chicago Press, Chicago. xx + 211 pp.

JAKSIC FM & JE JIMENEZ (1986) The conservation status of raptors in Chile. Birds of Prey Bulletin 3: 95-104.

MARDONES G (1995) Representatividad biogeográfica del sistema nacional de áreas silvestres protegidas del Estado. Memoria de Título, Instituto de Geografía, Pontificia Universidad Católica de Chile, Santiago. 124 pp.

MEDAIL F & P QUEZEL (1997) Hot-spot analysis for conservation of plant biodiversity in the Mediterranean basin. Annals of the Missouri Botanical Garden 84: 112-127.

MELLA JE (1994) Areas silvestres protegidas y la conservación de los mamíferos terrestres chilenos. M Sc thesis, Universidad de Chile, Santiago. vii + 115 pp.

METZGER PC (1983) Public-private partnerships for land conservation. Transactions of the forty-eight North American Wildlife Conference: 421-432.

MILLER S (1980) Human influences on the distribution and abundance of wild Chilean mammals: prehistoric-present. PhD dissertation, University of Washington, Seattle. xi + 433 pp.

MILLER SD, J ROTTMANN, KJ RAEDEKE & RD TABER (1983) Endangered mammals of Chile: status and conservation. Biological Conservation 25: 335-352.

MUÑOZ M, H NUÑEZ & J YAÑEZ, eds (1996) Libro rojo de los sitios prioritarios para la conservación de la diversidad biológica en Chile. Corporación Nacional Forestal, Santiago. iv + 203 pp.

MYERS N (1990) The biodiversity challenge: expanded hot-spots analysis. The Environmentalist 10: 243-256.

ORMAZABAL CS (1993) The conservation of biodiversity in Chile. Revista Chilena de Historia Natural 66: 383-402.

PRENDERGAST JR, RM QUINN, JH LAWTON, BC EVERSHAM & DW GIBBONS (1993) Rare species, the coincidence of diversity hotspots and conservation strategies. Nature 365: 335-337.

ROTTMANN J & MV LOPEZ-CALLEJA (1992) Estrategia nacional de conservación de aves. Servicio Agrícola y Ganadero, División de Proteción de los Recursos Naturales, Serie Técnica 1: 1-16.

SIMONETTI JA (1994) Threatened biodiversity as an environmental problem in Chile. Revista Chilena de Historia Natural 67: 315-319.

SIMONETTI JA (1998) Areas silvestres protegidas: ¿protegidas y protectoras?. In: Díaz-Pineda F, JM de Miguel & MA Casado (eds) Diversidad biológica y cultura rural en la gestión ambiental del desarrollo: 123-131. Mundi-Prensa, Madrid.

SIMONETTI JA & LE CORNEJO (1990) Economic and ecological changes: the prehistory of the Andean mountains of central Chile. In: Economic catalysts to ecological change. Working Papers, Center for Latin Amerian Studies, University of Florida: 65-77.

SIMONETTI JA & JE MELLA (1997) Park size and the conservation of Chilean mammals. Revista Chilena de Historia Natural 70: 213-220.

SIMONETTI JA & B SAAVEDRA (1998) Holocene variation in the small mammal fauna of central Chile. Zeitschrift für Säugetierkunde 63: 58-62.

SIMONETTI JA, MTK ARROYO, AE SPOTORNO & E LOZADA (eds) Diversidad biológica de Chile. Conicyt, Santiago.

VELOSO A, JC ORTIZ; J NAVARRO, H NUÑEZ, P ESPEJO & MA LABRA (1995) Reptiles. In: Simonetti JA, MTK Arroyo, AE Spotorno & E Lozada (eds) Diversidad biológica de Chile: 326-335. Conicyt, Santiago.

WELLS M & P BRANDON (1992) People and parks: linking protected area management with local communities. World Bank Publications, Washington DC. xii + 99 pp.

WESTERN D (1989) Conservation without parks: wildlife in the rural landscape. In: Western D & M Pearl (eds) Conservation for the twenty-first century: 158-165. Oxford University Press, New York.

WILLIAMS P, D GIBBONS, C MARGULES, A REBELO, C HUMPHRIES & R PRESSEY (1996) A comparison of richness hotspots, rarity hotspots, and complementary areas for conserving diversity of British birds. Conservation Biology 10: 155-174.