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Conservation status, rarity, and geographic priorities for conservation of Chilean mammals: an assessment

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Abstract

To assign priorities for the conservation of Chilean Non-volant Terrestrial Mammals (NTM) we developed a Conservation Priority Index (CPI). The analysis based on the CPI shows that 49 out of 82 species or 60% of Chilean NTM are of priority for conservation. These species are usually specialized in habitat requirements, a low percentage of their habitats are within the National System of Protected Areas, and have restricted geographic distributions. Out of these 49 species, 16 can be considered Fragile, and 33 as threatened (19 Vulnerable, 11 Endangered, and three Critical species). The level of threat of Chilean mammals, as assessed by CPI scores, was found to be affected by taxonomic affiliation, diet, and body mass. A complementary analysis, based on species rarity, points out the existence of 34 species of Chilean NTM with narrow geographic range and low average population density. Rarity status was not affected by food habits, but was affected by taxonomic affiliation. Carnivores were significantly rarer than rodents. The simultaneous application of the CPI and rarity analyses allowed us to identify seven species that are rare according to our analysis but do not have a CPI value high enough to be included in some of the categories discussed above. We propose to group these species under the category Indeterminate. The analysis at the level of Chilean ecoregions shows that total species richness is correlated with the number of rare and threatened species per ecoregion, but no relationship was detected between total species richness per ecoregion and the number of endemic species at the level of the country This suggests that a strategy for conserving species-rich areas most of the time will also protect a large proportion of rare and threatened species, although this would not provide protection for Chilean endemic species. The Matorral ecoregion, of which only 0.5% of its total area is currently protected, contains a large proportion of endemic species, hence its importance for conservation. A geographic strategy to protect Chilean NTM may have to consider the Matorral ecoregion as a priority along with the Puna, and Patagonian Steppe. In these latter two ecoregions is where most diversity is concentrated and where the largest number of rare and threatened species is found.

Keywords: Chile; Latin America; Mammals; Conservation priorities; Rarity

1. Introduction

Effective conservation action and planning should target species and geographical regions of conservation concern. By doing so, the preservation of species on the verge of extinction and the ecological systems wherein they are embedded is assured, thus merging coarse and fine-filter approaches (Noss, 1987). The identification of target species for conservation is usually carried out through the development of threatened species lists (e.g. Mace, 1994, 1995), which has proven to be useful tools in setting priorities for species conservation, providing basic guidelines for management (Oates, 1986; Schreiber et al., 1989). The identification of target geographic areas, on the other hand, is usually based on the characterization of geographic patterns of richness, endemisms, and current degree of endargenment (Ceballos and Brown, 1995). These endeavors have been difficult to implement in Latin American countries, where data on the geographic distribution and abundance of taxa are usually lacking. Mares (1986) and Ojeda and Mares (1989) point out that this is one of the major causes of current problems for biodiversity conservation in Latin America. However, recent steps to amend this situation have been taken by the Biodiversity Support Program et al. (1995) and Dinerstein et al. (1995), through the identification of geographic priorities for conservation of biodiversity in Latin America and the Caribbean. These authors classified the different ecoregions found in these areas, according to their current degree of

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threats by human activities and to their biological singularity. As a result of their analysis, high priority was assigned to tropical and temperate ecoregions, in agreement with earlier analyses based on geographic patterns of diversity and endemism (Redford et al., 1990; Mares, 1992).

Recent efforts have been made to evaluate the conservation status of mammalian species at the country level, based on indexes that rely on explicit and quantitative criteria, and whose results may be compared across countries (Ceballos and Navarro, 1991; Salazar et al., 1998). However, as acknowledged by these authors, this has been a difficult task because most of the time there are no quantitative data on population size, density, and trends, which lie at the base for estimating threatened status (Mace, 1994). Lack of data is an important factor militating against the application of well-grounded conservation policies in Latin America, but this should not stop efforts to use the data at hand and make an exhaustive search of the information needed. Even the identification of those species for which data are lacking may be a first step to solve this problem. In this paper we take this approach and evaluate the priorities for conservation at the level of ecoregions and of species in Chile based on the analysis of its mammalian fauna.

The evaluation of the conservation status of Chilean mammals has a short history (see Jaksic, 1997). Miller et al. (1973) reported on the status of Chilean ungulates, and Taber (1974), Miller (1980), Miller et al. (1983), and Glade (1988) reported on threatened mammals. Although valuable, these studies were based on qualitative data on distribution and abundance and of purported threats [see also Iriarte and Jaksic, 1986; and Iriarte et al. (1997) for a description of threats posed by trade and commercializations]. In this paper, we propose priorities for the conservation of non-volant Chilean mammals based on a Conservation Priority Index and on their commonness and rarity. We also set priorities for the conservation of the major ecoregions for these mammals. This is an attempt to introduce quantitative evidence on this subject, which at least in Chile, has been historically based on educated guesses for the majority of its fauna.

2. Materials and methods

2.1. Assessment of species priorities for conservation

To assess the conservation status of terrestrial Chilean mammals and to establish priorities for conservation, we developed an index [i.e. Conservation Priority Index (CPI)] similar to that used by other authors (Ceballos and Navarro, 1991; Reca et al., 1994; Salazar et al., 1998). However, in addition to qualitative variables, we included quantitative data on abundance and distribution. All nine variables (V_j) included in the analysis (Table 1) can take values ranging from 0 to 3. The value of the index for species i is simply the sum over all variable scores (V_j) for that species:

$$\mathrm{CPI}_i = \sum_{j=1}^{9} V_{(i,j)}.$$

The index can take values ranging from 0 to 27. Larger values imply a higher priority for conservation. Variables included in the analysis (Table 1) were: (1) Number of different ecoregions (HSP, modified from Dinerstein et al., 1995) where the species is found, taken as indicative of the degree of habitat specialization (see below for a description of Chilean ecoregions); (2) geographic distribution of the species in Chile (GD, in km^2); (3) average local abundance (AB, in ind/km^2); (4) endemism (END) based on the number of countries where the species is present; (5) taxonomic singularity (TSING) based on the degree of monotypy at the level of genus and family; (6) body mass (BM, in g); (7) presence of the species in the 1994 IUCN Red List of Endangered Animals (POL); (8) effect of human activities (HE), evaluated according to Miller et al. (1983), Iriarte and Jaksic (1986), Jiménez (1994), and Iriarte et al. (1997); and (9) degree of protection (DP), based on the percentage of area of the ecoregion inhabited by the species which lies within a protected area (National Parks, National Reserves, and Natural Monuments).

The variables included in the calculation of the CPI index are standard in this type of analysis (Ceballos and Navarro, 1991; Reca et al., 1994; Salazar et al., 1998). Endemic species are usually of conservation value because of their reduced geographic range, and degree of ecological specialization (e.g. Primack, 1993). Similarly, species that are the last extant members of a higher taxon or that represent evolutionary novelties, possess large conservation value because of the uniqueness of their genetic composition (e.g. Greene, 1994). We also included species' body mass in our assessment of species conservation value. Organisms of large body mass usually have higher extinction risks (Ceballos and Navarro, 1991; Primack, 1993; Brown, 1995). However, recent theoretical and empirical evidence point out that small species are equally or even more prone to extinction than large species (Brown et al., 1993; Marquet et al., 1995; Ceballos and Brown, 1995; Marquet and Taper, 1998) Based on this evidence, very large and very small species were assigned a high value (3) in the calculation of our CPI index (see Table 1). We also included in our analysis the presence and conservation status of particular species in the most recent IUCN list of endangered species (Groombridge, 1993). This feature was used as an indication of the global conservation concern of species.

Table 1
Variables and levels included in the calculation of the Conservation Priority Index (CPI)

Variables	Value 0	Value 1	Value 2	Value 3
HSP	⩾Four ecoregions	Three ecoregions	Two ecoregions	One ecoregion
GD	> 370,883 km^2	From 370,883 to 148,353 km^2	From 148.353 to 37,088 km^2	< 37,088 km^2
AB	> 1000 ind./km^2	100–1000 ind./km^2	10–100 ind./km^2	< 10 ind./km^2
END	Three or more countries	Two countries	One country	Only in Chile
TSING	Species in genera with > four species	Species in genera with two, three or four species	Species in monotypic genera	Species in monotypic family
BM	30–300 g	10–30 or 300–2500 g	3–10 or 2500–6300 g	< 3 g or > 6300 g
POL	Absent in IUCN Red List	Rare, Indeterminate or Inadequately Known	Vulnerable	Endangered
HE	Not known	Affected by livestock or exotic species	Control, subsistence or sport hunting	Habitat destruction and/or commercial hunting
DP	⩾50% of the area of ecoregions inhabited by the species is protected	50–30%	30–10%	< 10 %

HSP, Habitat specificity; GD, Geographic Distribution in Chile; AB, Local abundance; E, Endemism; TSING, Taxonomic singularity; BM, Body mass; POL, Presence in other lists; HE, Effects of humans; DP, Degree of protection.

The degree of anthropic influence upon species was also included in our analysis. The most important human perturbations for Chilean mammals are commercial harvesting and habitat destruction (Miller et al., 1983; Iriarte and Jaksic, 1986; Ojeda and Mares, 1989; Ceballos and Navarro, 1991; Primack, 1993; Jiménez, 1994; Iriarte et al., 1997). Consequently, these variables were given high scores in our CPI index (see Table 1). For the same reason, the percentage of a species' habitat enclosed within the Chilean National System of Protected Areas was evaluated. This variable was taken as an indicator of how buffered against current and future human perturbation mammalian species are within the country.

2.2. Rarity analysis

The degree of rarity characterizing a species is usually an indicator of extinction risk (Rabinowitz et al., 1986; Pimm et al., 1988; Arita et al., 1990; Primack, 1993; Gaston, 1994; Brown, 1995; Gaston and Blackburn, 1995) and provides a basis to identify threatened species (e.g. Rabinowitz, 1981; Arita et al., 1990; Daniels et al., 1991; Berg and Tjernberg, 1996). In general, species characterized by small geographic range, habitat specialization, and low abundance, are at higher risk of extinction than a widely distributed, habitat generalist, with high abundance. Because the assignment of conservation priorities based on the CPI index focus on traits other than those directly related to rarity, we performed a separate rarity analysis based on the scheme proposed by Rabinowitz (1981), to identify those species likely to be extinction-prone. We include this separate analysis to provide a standard for comparison and calibration of the results obtained from application of the CPI index to assign priorities for conservation and extinction threats.

The distinction between low and high abundance species and between species with narrow vs wide geographic ranges was based on median values for each variable (see Arita et al., 1990). We additionally ranked density and geographic range values and then developed an index which is the average of both ranks (see Dobson and Yu, 1993; Gaston and Blackburn, 1995). This rarity index was then correlated against species CPI values. The analysis was performed using only those species for which data on density was available.

2.3. Geographic priorities

In order to assess the geographic priorities for conservation of Chilean mammals we distinguished seven ecoregions within the country, following the classification proposed by the Biodiversity Support Program et al. (1995) and Dinerstein et al. (1995). This was complemented by information presented by Gajardo (1994) in order to obtain a clear distinction of ecoregion boundaries (Fig. 1). For each ecoregion we determined seven attributes: (1) area within Chile, which was estimated by planimetry using a map of Chile scale 1:10,000,000; (2) number of national endemics (i.e. number of species endemic to Chile present in the ecoregion); (3) number of regional endemics (i.e. number of species endemic to an ecoregion, but not necessarily endemic to Chile); (4) species richness; (5) number of threatened species (i.e. CPI > 12); (6) degree of protection, assessed as the percentage of each ecoregion within the Chilean System of National Protected Areas, calculated on a map scale 1:2,000,000; and (7) number of rare species.

Each ecoregion was ranked according to these attributes. A higher rank was assigned to high values of each attribute. In case of ties, each ecoregion was assigned the mean rank.

2.4. Data sources

Data on abundance, distribution, diet, and body mass for Chilean mammals were compiled from different sources (see Appendix A). Nomenclature followed Wilson and Reeder (1993), with the exception of Didelphimorphia, Microbiotheriidae, and Paucituberculata, which were pooled into Marsupialia. In addition we included the species *Pseudalopex fulvipes* (Medel et al., 1990; Yahnke et al., 1996) and *Ctenomys coyhaiquensis* (Kelt and Gallardo, 1994), and followed recommendations made by Kelt et al. (1991) and by Spotorno et al. (1994) regarding species of the genera *Eligmodontia* present in Chile. We included only Nonvolant Terrestrial Mammals (NTM hereafter) from continental Chile. We excluded bats and sea otters because of their contrasting ecological and life history traits, and because of the scarce information available. We distinguished five trophic categories: herbivores, carnivores, omnivores, insectivores, and frugivore-granivores.

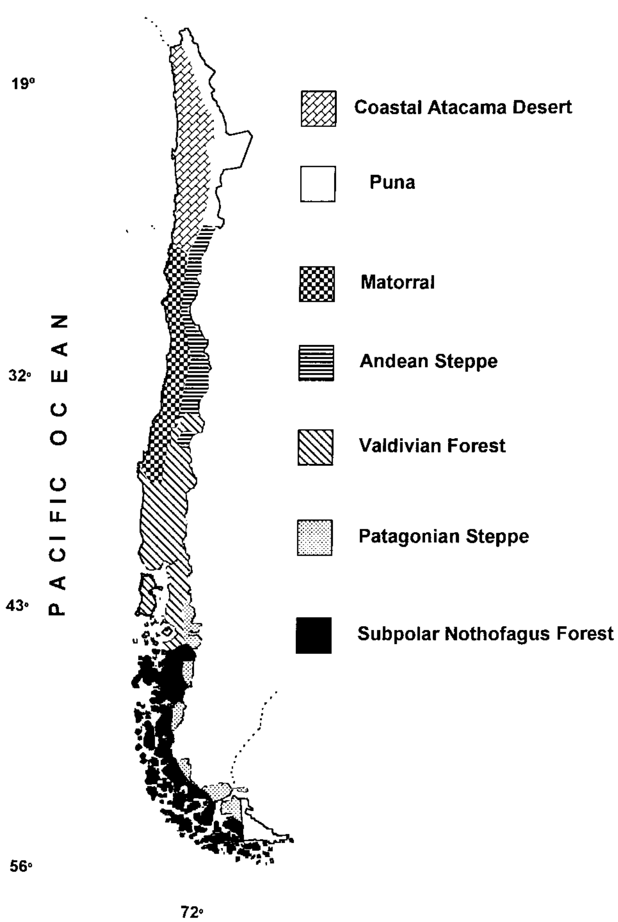

Fig. 1. Geographic distribution of the seven major ecoregions of Chile.

3. Results

3.1. Conservation status

We applied the CPI index to all 82 species of Chilean NTM (Table 2) although information on population density was available only for 50 species (Appendix A, Table 2). Using these species, we did a regression analysis between $\log_{10}$ density and $\log_{10}$ body mass (Fig. 2). We found a highly significant negative relationship between both variables ($F_{1,48} = 68.1$, $p < 0.001$) as has been reported in the literature (Damuth, 1981; Silva and Downing, 1995). Using this regression we predicted the density of the other 32 species.

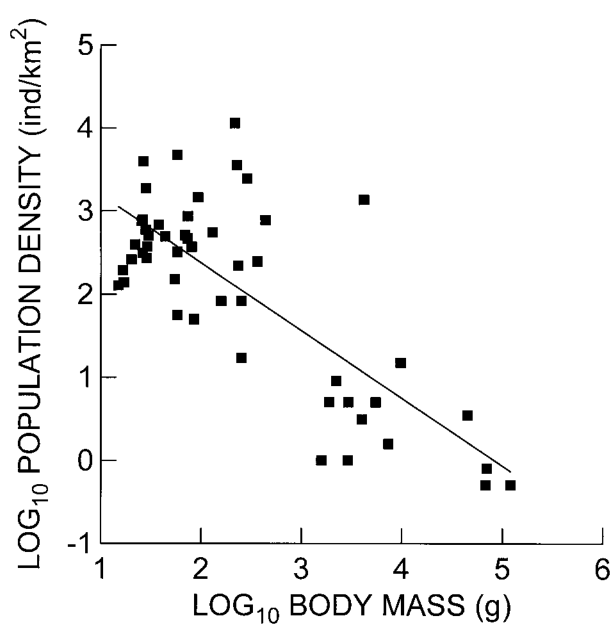

Fig. 2. Allometric relationship between population density [D (ind/km^2] and body mass [M (g)] for 50 species of Chilean Non-volant Terrestrial Mammals (NTM). The regression equation relating both variables is: Log_{10} (D) = 4−0.815 Log_{10} (M). ($r = 0.766$, $F_{[1,48]} = 68.1$, $p < 0.0001$, $n = 50$).

Table 2
Species scores in variables included in the calculation of the Conservation Priority Index (CPI)

Species	HSP	GD	AB	END	TSING	BM	POL	HE	DP	CPI	Category
Hippocamelus antisensis[a]	2	3	3	1	1	3	1	3	3	20	C
Pseudalopex fulvipes	3	3	3	3	0	2	0	3	2	19	C
Chinchilla lanigera	3	3	1	3	1	1	1	3	3	19	C
Vicugna vicugna	3	2	2	1	2	3	1	2	2	18	E
Oreailurus jacobita[a]	2	2	2	1	2	2	1	3	3	18	E
Hippocamelus bisulcus	0	2	3	2	1	3	3	2	2	18	E
Rhyncholestes raphanurus	3	3	1	3	2	1	0	3	2	18	E
Lontra provocax	2	2	3	2	2	2	2	1	1	17	E
Lagidium wolffsohni[a]	3	3	2	1	1	2	0	2	2	16	E
Chinchillula sahamae[a]	3	3	1	1	2	0	0	3	3	16	E
Pudu puda	2	1	2	2	1	3	1	2	2	16	E
Octodon lunatus	3	2	1	3	1	0	0	3	3	16	E
Lagidium peruanum[a]	3	3	2	1	1	1	0	2	3	16	E
Chinchilla brevicaudata[a]	3	2	1	1	1	1	1	3	3	16	E
Galenomys garleppi[a]	3	3	1	2	3	0	0	0	3	15	V
Oncifelis guigna	2	1	3	2	1	1	1	2	2	15	V
Neotomys ebriosus	3	3	2	1	3	0	0	0	3	15	V
Lama guanicoe	0	2	2	0	2	3	0	3	3	15	V
Oncifelis geoffroyi[a]	2	2	3	0	1	2	0	2	2	14	V
Pseudalopex griseus	0	1	3	1	0	2	2	3	2	14	V
Abrocoma bennetti	3	2	2	3	1	0	0	0	3	14	V
Octodontomys gliroides	3	3	2	1	2	0	0	0	3	14	V
Dromiciops gliroides	3	2	1	2	3	1	0	0	2	14	V
Abrocoma cinerea	2	2	2	1	1	0	0	3	3	14	V
Puma concolor	0	1	3	0	2	3	0	2	2	13	V
Oncifelis colocolo	0	1	3	0	1	2	1	3	2	13	V
Chelemys megalonyx[a]	1	1	1	3	1	0	0	3	3	13	V
Euneomys mordax[a]	3	3	1	2	1	0	0	0	3	13	V
Irenomys tarsalis	3	2	1	2	3	0	0	0	2	13	V
Aconaemys sagei[a]	3	3	1	2	1	0	0	0	3	13	V
Phyllotis osgoodi[a]	3	3	1	3	0	0	0	0	3	13	V
Geoxus valdivianus	0	1	1	2	3	1	0	3	2	13	V
Chaetophractus vellerosus[a]	3	2	2	1	1	1	0	0	3	13	V
Spalacopus cyanus[a]	1	2	1	3	2	0	0	0	3	12	F
Ctenomys opimus	3	3	1	1	0	1	0	0	3	12	F
Octodon degus	3	2	0	3	1	0	0	0	3	12	F
Eligmodontia puerulus	3	2	1	1	1	1	0	0	3	12	F
Chaetophractus villosus[a]	2	2	3	1	1	1	0	0	2	12	F
Eligmodontia morgani	2	2	1	2	1	1	0	0	3	12	F
Ctenomys maulinus[a]	3	3	1	2	0	0	0	0	3	12	F
Auliscomys boliviensis	3	3	1	1	1	0	0	0	3	12	F
Calomys lepidus	3	2	1	1	1	1	0	0	3	12	F
Galictis cuja	0	1	3	0	1	1	0	3	3	12	F
Zaedyus pichiy[a]	2	2	2	1	2	1	0	0	2	12	F
Lagidium viscacia[a]	0	1	2	1	1	1	0	3	3	12	F
Andinomys edax[a]	2	3	1	0	2	1	0	0	3	12	F
Euneomys petersoni[a]	3	3	1	2	1	0	0	0	2	12	F
Ctenomys coyhaiquensis[a]	3	3	1	3	0	0	0	0	2	12	F
Microcavia niata[a]	3	3	1	1	1	0	0	0	3	12	F
Conepatus chinga	0	0	3	0	1	1	0	3	3	11	NP
Pseudalopex culpaeus	0	0	3	0	0	3	0	3	2	11	NP
Octodon bridgesi	1	2	0	2	1	0	0	3	2	11	NP
Akodon markhami[a]	3	3	1	3	0	1	0	0	0	11	NP
Thylamys pallidior	3	2	1	1	0	1	0	0	3	11	NP
Galea musteloides	3	3	0	1	1	0	0	0	3	11	NP
Akodon albiventer	3	2	1	1	0	1	0	0	3	11	NP
Cavia tschudii[a]	3	3	1	1	0	0	0	0	3	11	NP
Akodon hershkovitzi[a]	2	3	1	3	0	1	0	0	1	11	NP
Auliscomys sublimis[a]	3	2	1	1	1	0	0	0	3	11	NP
Conepatus humboldtii[a]	1	1	2	1	1	1	0	2	2	11	NP
Myocastor coypus	0	1	0	0	2	2	0	3	2	10	NP

(Table continued on next page)

Table 2 (*continued*)

Species	HSP	GD	AB	END	TSING	BM	POL	HE	DP	CPI	Category
Phyllotis magister	2	2	1	2	0	0	0	0	3	10	NP
Ctenomys fulvus [a]	2	2	2	1	0	0	0	0	3	10	NP
Aconaemys fuscus	2	2	1	2	1	0	0	0	2	10	NP
Euneomys chinchilloides	1	2	2	2	1	0	0	0	2	10	NP
Ctenomys magellanicus [a]	3	2	1	2	0	0	0	0	2	10	NP
Microcavia australis	3	2	0	1	1	0	0	0	2	9	NP
Phyllotis darwini	1	2	0	3	0	0	0	0	3	9	NP
Chelemys macronyx	1	2	1	2	1	0	0	0	2	9	NP
Chroeomys andinus	1	1	1	1	1	1	0	0	3	9	NP
Akodon sanborni	2	2	1	2	0	1	0	0	1	9	NP
Lyncodon patagonicus [a]	1	3	1	1	1	0	0	1	1	9	NP
Oligoryzomys magellanicus [a]	3	2	1	2	0	1	0	0	0	9	NP
Akodon lanosus [a]	2	2	1	1	0	1	0	0	1	8	NP
Reithrodon auritus	1	2	1	1	2	0	0	0	1	8	NP
Thylamys elegans	1	1	1	1	0	1	0	0	3	8	NP
Akodon xanthorhinus	2	2	0	1	0	1	0	0	1	7	NP
Auliscomys micropus	0	1	0	2	1	0	0	0	2	6	NP
Oligoryzomys longicaudatus	1	1	1	1	0	1	0	0	1	6	NP
Akodon longipilis	0	1	1	2	0	0	0	0	2	6	NP
Akodon olivaceus	0	0	0	2	0	1	0	0	2	5	NP
Phyllotis xanthopygus	0	1	1	1	0	0	0	0	2	5	NP

Category: C, Critical; E, Endangered; V, Vulnerable; F, Fragile; NP, No immediate priority.
[a] Species whose density values were estimated.

Values of the CPI index were normally distributed (Shapiro–Wilk's test $W=0.96$, $p=0.126$). They ranged from 5 to 20 out of a theoretical range between 0 and 27. This implies that there is no species with scores of either all 0 or all 3 for all nine variables. Thus, no species is completely "safe" nor critically endangered. We assumed that species of priority for conservation possess CPI values equal to or higher than 12. This cutoff point corresponds to the median and mean of the CPI frequency distribution. In addition, we chose this cutoff value because all species with a CPI value of 12 or higher, except for the edentate *Zaedyus pichiy*, scored 3 in one or more variables. Under this criterion 49 out of 82 species or 60% of Chilean NTM are of priority for conservation. This is the result of most species scoring high in the Degree of Habitat Protection, Habitat Specialization, and Geographic Distribution (Table 2). Thus, species of conservation priority are specialized in habitat requirements, a low percentage of their habitats is within the National System of Protected Areas, and have restricted geographic distribution.

Species with CPI values $\leqslant 11$ were categorized as of no immediate conservation priority, whereas species with $\text{CPI}=12$ were considered Fragile ($n=16$). We classified as threatened those species whose CPI was higher than 12 ($n=33$). These species were assigned to the categories Vulnerable, Endangered, and Critical in sequence of increasing CPI values. Vulnerable species were defined as having a CPI value between 13 and 15, Endangered 16–18, and Critical 19–21. According to this classification, there are 16 Fragile, 19 Vulnerable, 11 Endangered, and three Critical species.

The number of threatened species (i.e. with status of either Vulnerable, Endangered, or Critical) in the different families is presented in Fig. 3. The family with most species in these categories is Muridae with six species, followed by Chinchillidae, and Felidae, both with five species each. However, in terms of *proportions*, the more important families are Felidae, Cervidae, Camelidae, Chinchillidae, Caenolestidae, Microbiotheriidae, and Abrocomidae. For these families, 100% of their species found in Chile (and in the world in the case of Microbiotheriidae) have conservation problems.

A one-way ANOVA for all species considered as of priority for conservation, using taxonomic order as a factor, detected a significant effect ($F_{3,46}=6.2$, $p=0.0012$) with rodents having significantly lower CPI scores than artiodactyls (Scheffé-test $p=0.0078$). A similar analysis using diet as a factor, detected a significant effect ($F_{4,45}=8.68$, $p=0.000028$) with omnivores having significantly lower CPI scores than herbivores, carnivores, and insectivores (Scheffé-test, $p=0.0012$, 0.0026, and 0.029, respectively).

The median of the body size distribution (in $\log_{10}$) for threatened species was larger than the observed for Chilean NTMs (2.7 vs 2.1, Fig. 4). Thus implying that threatened species tend to have a larger body mass. In fact, 100% of the species >8 kg are classified as threatened. To assess the statistical significance of this trend we performed a bootstrap analysis of the observed body

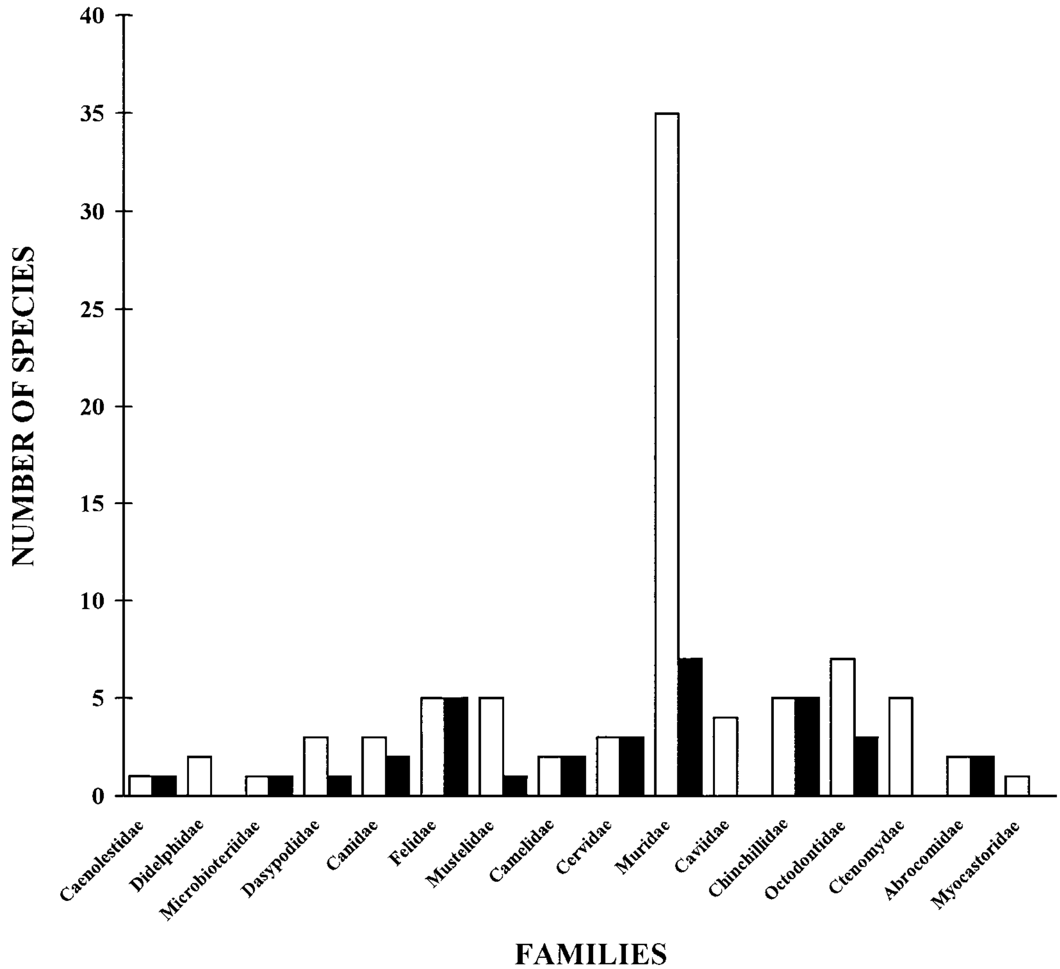

Fig. 3. Distribution of total number of species (white bars) and the number of threatened species (black bars) among mammalian families in Chile.

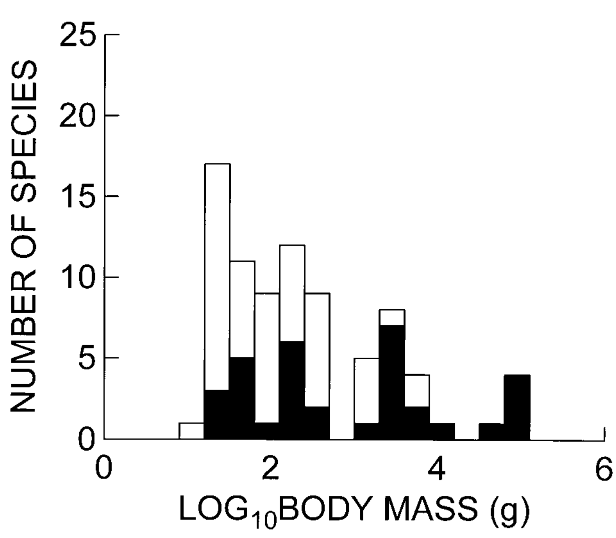

Fig. 4. Body mass distribution for all Chilean NTM and for threatened species (CPI > 12) in black.

mass distribution of NTMs for the entire country. We took 1000 samples of size 33 (the observed number of threatened species) and computed at each run the median of the resulting distribution. The probability of obtaining a median value as extreme or more extreme than the observed for threatened species by random sampling alone was $p = 0.0067$.

3.2. Rarity analysis

The analysis of rarity (Table 3) shows the existence of 34 species of Chilean NTM that have both narrow geographic range and low population density. Out of these, 21 are habitat specialists and 12 are habitat generalists. Interestingly, 27 (79%) of these species have CPI scores $\geqslant 12$. This is indicative that CPI values agree with rarity status. Nevertheless, it is interesting to note that there are 22 species that according to their CPI value are of conservation priority but are not rare. These species, including the rodents *Geoxus valdivianus,* *Octodon degus, Eligmodontia puerulus, Chinchilla lanigera, Irenomys tarsalis,* the marsupials *Rhyncholestes raphanurus* and *Dromiciops gliroides*, the cervid *Pudu puda,* the camelid *Lama guanicoe,* and the carnivores *Lontra provocax, Galictis cuja*, *Oncifelis guigna, Pseudalopex griseus, Puma concolor* and *Oncifelis colocolo* are either of phylogenetic singularity, endemic, highly impacted by human activities, or not adequatedly protected in National Parks or preserves. Similarly, there are seven species that are rare but their CPI is <12. These "mismatches" illustrate that both analyses are not redundant but complement each other. From the stand point of their local population density and geographic range those seven species should be included in one of the categories of conservation priority (see Discussion).

Table 3
Rarity classification for Chilean nonvolant terrestrial mammals (species with CPI$\geqslant$12 in boldface)

Geographic range	Local abundance	
	High	Low
Wide		
Habitat Specialist	***Irenomys tarsalis***	–
	Dromiciops gliroides	
Habitat Generalist	***Eligmodontia puerulus***	***Lontra provocax***
	Phyllotis xanthopygus	***Oncifelis colocolo***
	Akodon olivaceus	***Lama guanicoe***
	Thylamys elegans	***Oncifelis guigna***
	Phyllotis darwini	*Chroeomys andinus*
	Auliscomys micropus	***Pudu puda***
	Akodon longipilis	***Lagidium viscacia***
	Oligoryzomys longicaudatus	*Conepatus chinga*
	Myocastor coypus	***Puma concolor***
	Chelemys megalonyx	***Galictis cuja***
	Geoxus valdivianus	***Pseudalopex griseus***
	Chelemys macronyx	*Pseudalopex culpaeus*
	Reithrodon auritus	*Cavia tschudii*
Narrow		
Habitat Specialist	*Akodon albiventer*	***Neotomys ebriosus***
	Auliscomys sublimis	***Chinchillula sahamae***
	Galea musteloides	***Auliscomys boliviensis***
	Galenomys garleppi	***Chaetophractus vellerosus***
	Phyllotis osgoodi	*Thylamys pallidior*
	Chinchilla lanigera	***Ctenomys opimus***
	Octodon degus	***Chinchilla brevicaudata***
	Euneomys mordax	***Microcavia niata***
	Rhyncholestes raphanurus	***Lagidium peruanum***
		Calomys lepidus
	Akodon markhami	***Vicugna vicugna***
	Oligoryzomys magellanicus	***Abrocoma bennetti***
		Octodon lunatus
	Microcavia australis	***Aconaemys sagei***
	Euneomys petersoni	***Ctenomys maulinus***
		Pseudalopex fulvipes
		Ctenomys magellanicus
		Conepatus humboldtii
		Lagidium wolffsohni
		Ctenomys coyahiquensis
Habitat Generalist	***Andinomys edax***	***Hippocamelus antisensis***
	Phyllotis magister	*Ctenomys fulvus*
	Octodon bridgesi	***Octodontomys gliroides***
	Aconaemys fuscus	***Abrocoma cinerea***
	Akodon sanborni	***Spalacopus cyanus***
	Akodon lanosus	***Oreailurus jacobita***
	Akodon xanthorhinus	***Zaedyus pichiy***
	Akodon hershkovitzi	***Hippocamelus bisulcus***
		Euneomys chinchilloides
		Lyncodon patagonicus
		Chaetophractus villosus
		Eligmodontia morgani
		Oncifelis geoffroyi

In general, CPI scores correlate well with the rarity index (Spearman $r_s=-0.586$, $p=0.0001$). However, because both variables were also correlated with body mass (Spearman $r_s=-0.40$, $p=0.004$ for CPI, and $r_s=0.3$, $p=0.03$ for the rarity index) we removed this variable by performing partial correlation analysis. After controlling for the effect of body mass, both variables were still highly correlated (Partial Spearman $r_s=-0.53$, $p=0.0001$). Thus, species with large CPI values tend to be very rare in terms of density and geographic distribution.

The observed frequencies of species in different categories of geographic range and abundance show a significant departure from random ($\chi^2=13.9$, d.f.$=3$, $p=0.003$). This departure is mostly due to the large number of rare species with narrow geographic ranges and low abundance. No significant differences in the rarity index were observed across diet categories (Kruskal–Wallis H $(4,50)=8.6$, $p=0.0718$). However, an order effect was detected (Kruskal–Wallis H $(3,50)=12.45$, $p=0.006$), which was the result of a significant difference between carnivores and rodents (Observed difference$=17.2$, Critical difference$=14.4$, $p<0.05$). The former were characterized by a lower rarity index (i.e. high rarity) than the latter.

3.3. Analysis at the ecoregion level

We recognized seven ecoregions within continental Chile: Puna (P), Atacama Desert (D), Matorral (M), Andean Steppe (AS), Valdivian Forest (VF), Subpolar *Nothofagus* Forest (SpF), and Patagonian Steppe (PS) (Fig. 1). Of these, the Puna, Patagonia and Andean Steppe have the highest numbers of species (34, 30, and 30, respectively, Table 4) whilst, the Atacama Desert has the lowest (18). Regarding the number of regional endemic species (Table 4), Puna has the highest with 17 species followed by Patagonia, Matorral, and Valdivian Forest with six, five, and five species, respectively. The Atacama Desert has only one endemic species. On the other hand, the number of national endemic species are highest in the Matorral, with seven species (Table 4).

The total number of threatened species (i.e. CPI>12) per ecoregion ranges from four to 16. Larger numbers

Table 4
Characteristics of the seven major ecoregions found in Chile

Variables	Ecoregions						
	D	P	M	AS	VF	SpF	PS
Area in Chile (thousand km^2)	135.2 (3)	91.4 (5)	152.3 (2)	55.5 (7)	158.6 (1)	122.7 (4)	60.9 (6)
National endemism (number of species)	1 (2)	1 (2)	7 (7)	1 (2)	2 (4.5)	2 (4.5)	3 (6)
Regional endemism (number of species)	1 (1)	17 (7)	5 (4)	4 (3)	6 (5.5)	2 (2)	6 (5.5)
Species richness	18 (1)	34 (7)	22 (3)	30 (5.5)	27 (4)	21 (2)	30 (5.5)
Species with CPI >12 (number of species)	5 (2)	16 (7)	7 (3)	9 (4)	11 (6)	4 (1)	10 (5)
Degree of protection	0.8 (6)	6.6 (4.5)	0.5 (7)	6.6 (4.5)	24 (2)	73 (1)	14 (3)
Number of rare species	1 (1)	7 (5.5)	3 (3)	7 (5.5)	5 (4)	2 (2)	8 (7)
Total rank	16	38	29	31.5	27	16.5	38

D, Coastal Atacama Desert; P, Puna; M, Matorral; AS, Andean Steppe; VF, Valdivian Forest; SpF, Subpolar *Nothofagus* Forest; PS, Patagonian Steppe. Ranks for each attribute are shown in parentheses.

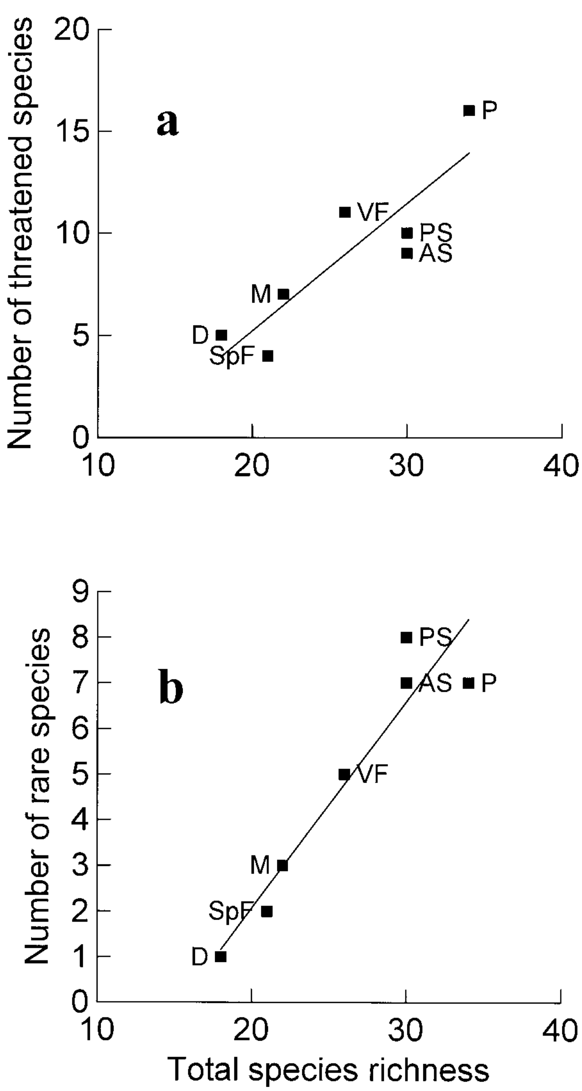

Fig. 5. Relationship between (a) the number of threatened species and (b) rare species and total species richness per ecoregion. Abbreviations as in Table 4.

of species are predominantly found in the Puna, Valdivian Forest, and Patagonian Steppe, with 16, 11, and 10 species, respectively (Table 4). In general, the number of threatened species and the number of rare species (i.e. species with low abundance and narrow geographic ranges) are positively correlated with the total number of species found in each ecoregion (Fig. 5a and b) and between themselves (Pearson's $r=0.77$, $n=7$, $p=0.042$). However, rare species are concentrated in the Patagonian Steppe, Andean Steppe, and Puna, with eight, seven, and seven species, respectively, whereas species with CPI > 12 are concentrated in the Puna, Valdivian Forest, Patagonian Steppe, and Andean Steppe, with 16, 11, 10, and nine species, respectively.

The analysis of priorities based on ecoregions ranks (Table 4) identify the Puna and the Patagonian Steppe as the most important ecoregions, followed by the Andean Steppe, and the Matorral.

4. Discussion and conclusions

The analysis of conservation priorities, extinction threats, and identification of geographic areas of importance for biodiversity is essential to assure the present and future existence of many species of mammals in South America. Lack of adequate data upon which conservation guidelines should be based has been identified as an important threat to biodiversity in this area (Mares, 1986). Fortunately, during the last decade there has been an increase in both the number of specialists and of publications that allow a start to be made in quantitative analyses of the conservation status of the South American biota (e.g. Ceballos and Navarro, 1991).

We classified threatened species (CPI > 12) in three categories: Vulnerable, Endangered, and Critical. We recognize that a classification of threatened status should ideally be based on quantitative assessments of extinction risks and threats based on the theory of extinction times for populations, as proposed by Mace and Lande (1991). However, and at least for South American countries, several species will probably go extinct before reliable estimates of their extinction risk become available, or even before they are described as extant (Diamond, 1987). This is exemplied by the three species we classified as Critical, *Hippocamelus antisensis*, *Pseudalopex fulvipes*, and *Chinchilla lanigera*. The taruca *H. antisensis* is found in northern Chile where only 200 individuals survive (Miller et al., 1983), Darwin's fox *P. fulvipes* is restricted to Chiloe island, where estimated numbers may be close to 500 individuals (Yahnke et al., 1996), and to one location in the mainland with fewer than 50 individuals (Medel et al., 1990; Jiménez et al., 1991). This species is threatened by human encroachment and deforestation of its natural habitat. Finally, the once widespread chinchilla *C. lanigera*, persists in the wild in 42 discrete colonies in semi-arid Chile (Jiménez, 1995), where both the number and size of colonies are decreasing (Jiménez, 1996). For these three species, at least, the Critical status seems adequate.

Our criteria for choosing a CPI cutoff point of 12, and for assinging scores to the variables on which it is based, are certainly arbitrary. However, at some point all criteria for assessing conservation priority and status, such as those used by UICN (Groombridge, 1993) and Mace and Lande (1991) are arbitrary too (see also Millsap et al., 1990; Ceballos and Navarro, 1991; Dinerstein et al., 1995; Salazar et al., 1998). A different issue is if the variables used are appropriate for the task of assigning priorities. We think our variables are apropriate to the extent that they relate to current and future extinction threats and "quality or importance" of taxa (e.g. taxonomic uniqueness, endemicity, etc.). This arbitrariness stems from our lack of knowledge about the precise functional relationship between extinction probability and variables such as geographic range size and abundance across species. In our case, we know that species with low CPI scores would tend to be at low risk, while the opposite holds for taxa with high CPI scores. In between these extremes we are uncertain. We set the cutoff point at the median (CPI = 12) of the distribution of CPI scores (which is also the mode of our distribution because it is normal). Thus, at least the procedure for choosing such a cutoff is clear. We offer two arguments in favor of this cutoff point. First, all species (but one) with a value of CPI = 12 scored high (= 3) in at least one of the variables used to compute the CPI. This means that these species are either habitat specialists, have a very small geographic range, are endemic, are the only species in their families, are very small or very large, are already classified as endangered, are highly impacted by humans, or are not protected in national parks or preserves. We think that any of these attributes will at least render these species as Fragile. Second, all species that already had a conservation status of critical, threatened or vulnerable according to IUCN also had a CPI > 12.

The analysis of priorities for conservation and threat of a particular fauna is intrinsically a never-ending dynamic process. Species are continually moving among categories depending on the amelioration or increase in particular factors that impinge on their numbers and distribution. This is especially the case in Latin America, where any increase in knowledge on particular taxa could result in a change in conservation category. In this regard the analysis we performed for Chilean NTM, for which 32 species (40%) of the total NTM lack data on density, should be considered as only a first step in a process that should be iterated in the light of new data. It is important to note that our estimates of density for those 32 species without data, based on allometric relationships, could be an important source of bias in our analysis. These species are likely to have lower densities than estimated, which is probably the main reason we lack an empirical density estimate in the first place. If this is true, then the number of rare NTM is likely to increase. Thus, our analysis is conservative.

The level of threat of Chilean mammals, as assessed by their CPI scores, was found to be affected by taxonomic affiliation, diet, and body mass. This illustrates the complex interaction of factors affecting the conservation status of species. While all Chilean artiodactyls have CPI > 12, this is valid for only 30% of the rodent species. This, in addition to a positive correlation between size and CPI and the results of the bootstrap analysis, indicates that species of large size are usually important from a conservation standpoint. However, 51.5% of threatened species (CPI > 12) are of small size (< 250 g) emphasizing that small mammals are also a priority for conservation, as suggested by Ceballos and Brown (1995). Diet was also related to CPI values. A comparison of CPI scores across trophic groups identifies omnivores as having significantly lower CPI. This result suggests that species of generalized trophic habits may be of lower priority for conservation at least in Chile. With regard to rarity, diet had no significant effect. However, a taxonomic affiliation effect was detected. Carnivores were significantly rarer than rodents. A similar result was obtained by Berg and Tjernberg (1996) for Swedish vertebrates. A cautionary note is needed here. All our comparisons are based on attributes of species within Chilean political boundaries, which does not necessarily characterize species across their entire range. Thus, the rarity of species such as *Oncifelis geoffroyi* and *Oreailurus jacobita*, which are usually found in low numbers, is largely because of their marginal distribution in Chile.

The analysis of rarity we performed was complementary to the use of the CPI score. Although to be rare does not necessarily imply a threatened status (Gaston, 1994), rare species possess traits that are usually correlated with extinction proneness (Rabinowitz, 1981; Arita et al., 1990; Reed, 1992; Arita, 1993; Primack, 1993; Gaston, 1994; Brown, 1995; Lawton, 1995). Rarity is an important parameter for the assignment of species to different categories of threats, but not a category in itself (Mace and Lande, 1991; Gaston, 1994). In our study, much of the biological basis to assign conservation status based on a rarity analysis was retained in the CPI index. However, there are important discrepancies between both analyses. The CPI analysis includes variables of importance to set priorities for conservation but not related to distribution and abundance. This explains why there are species which although not rare have CPI > 12. However, the existence of rare species with CPI < 12 is more difficult to understand. This likely is the result of abundance and geographic range being coded differently by each analysis. In the rarity analysis a species of low abundance and narrow geographic range has values for both variables that are lower than their respective medians, calculated in reference to the entire set of species included in the analysis. Instead, for the calculation of CPI, abundance was coded using three different abundance classes differing by one order of magnitude, and geographic range was coded in three arbitrary classes. This discrepancy reflects our ignorance on how both variables relate to extinction probability across their entire range of variability.

4.1. Geographic priorities for conservation

The analysis of ecoregions in Chile shows that, in general, those areas located along the eastern side of the country, such as the Puna, Patagonian Steppe, and Andean Steppe, harbor great diversity of species, are of small areal extent, and contain a large number of rare species. This is because these ecoregions are less isolated, and have a large proportion of their areas in nearby species-rich countries such as Argentina and Bolivia. All these areas along the Andean mountain range, and specially the Puna, have long been recognized as important centers of diversification of mammalian species (e.g. Muller, 1973; Pearson and Ralph, 1978; Reig, 1986; Marquet, 1989, 1994; Moreno et al., 1994).

In terms of the proportion of national territory allocated to protected areas, Chile ranks second in Latin America and seventh highest in the world (WRI, 1990). Nevertheless, the degree of coverage afforded by the current National System of Protected Areas is inadequate (Valencia et al., 1987; Simonetti and Armesto, 1991; Ormazábal, 1993; Mella and Simonetti, 1994). This is particularly clear for ecoregions such as the Puna and Andean Steppe, with only 6.6% of their area within protected areas. However, an even more critical situation affects the Matorral ecoregion, of which only 0.5% of its total area is currently protected. This area is not particularly rich in species of terrestrial mammals nor does it harbor large numbers of rare or threatened species, but it contains a large proportion of endemic species, and so is important for conservation. A geographic strategy to protect Chilean NTM should consider the Matorral ecoregion as a priority together with the Puna, Patagonian Steppe, and Andean Steppe.

We found total species richness to be correlated with the number of rare and threatened species per ecoregion. A similar relationship was reported by Berg and Tjernberg (1996) for terrestrial vertebrates in Sweden. However, it is likely that this relationship would disappear at a finer spatial resolution (e.g. Williams et al., 1996). The number of species unique to a particular ecoregion, or regional endemics, was positively correlated with total species richness. However, no relationship was detected between total species richness per ecoregion and the number of national endemic species (see also Ceballos and Rodriguez, 1993; Ceballos and Brown, 1995; Ceballos et al., 1998). This is the result of most Chilean endemic species being restricted to the Matorral ecoregion. These data suggest that a strategy for conserving species-rich areas will most of the time also protect a large proportion of rare and threatened species, but would not afford protection for Chilean endemics. The lack of correlation between areas regarding attributes related to conservation value has recently been pointed out by Prendergast et al. (1993) for Britain, by Dobson et al. (1997) for North America, and by Van Jaarsveld et al. (1998) for South Africa, based on the analysis of several taxa of both plants and animals. We fully agree with these authors, in that conservation strategies based solely on variables such as diversity and rarity, and restricted to one or a few taxonomic groups, will fail to provide adequate protection for many organisms unless reliable indicator taxa can be identified (e.g. Dobson et al., 1997). In this regard, it is highly desirable to extend analyses such as ours to other taxonomic groups inhabiting Chile, and to finer spatial scales to provide the data needed to better preserve Chilean biodiversity.

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Appendix

Data and sources for Chilean Nonvolant Terrestrial mammals

Species	Weight (g)	Diet	G. Range in Chile (thousands of km^2)	Density (ind/km^2)	Ecoregion	Source
Marsupialia						
Didelphidae						
Thylamys elegans	28.9	O	212.5	370	1,3,5	1,8,28,33
Thylamys pallidior	14.9	O	87.5	128	2	19,28
Microbiotheriidae						
Dromiciops gliroides	25.45	I	100	749	5	1,14,22,23,25
Caenolestidae						
Rhyncholestes raphanurus	25.9	I	35.2	312	5	1,14,22,23,25,29
Xenarthra						
Dasypodidae						
Chaetophractus vellerosus	2150	O	48.4	19.2[a]	2	1,16,20,33
Chaetophractus villosus	2370	O	45.3	17.8[a]	4,7	1,11,16,20,33
Zaedyus pichiy	1020	O	72.7	35.3[a]	4,7	1,11,16,20,33
Carnivora						
Canidae						
Pseudalopex culpaeus	7237	C	632	1.58	1,2,3,4,5,6,7	1,25,32,33,37,38,40
Pseudalopex griseus	3067	C	339.8	3.1	1,2,3,4,5,6,7	1,25,32,33,37,38,40
Pseudalopex fulvipes	2896	C	7.3	1	5	1,9,25,39
Mustelidae						
Galictis cuja	1580	C	252.3	1	1,2,3,4,5	1,20,25
Lyncodon patagonicus	225	C	43.8	121[a]	4,6,7	1,11,20
Lontra provocax	5500	C	98.4	5	5,6	1,11,20,25
Conepatus humboldtii	328	C	42.2	89[a]	7	1,11,20,25
Conepatus chinga	1885	O	209.4	5	1,2,3,4,5	1,20,25
Felidae						
Oncifelis colocolo	2950	C	113.3	5	2,3,4,7	1,11,20,25
Oncifelis geoffroyi	3590	C	49.2	12.7[a]	4,7	1,11,20,25
Oncifelis guigna	2230	C	168.8	9	5,3	1,20,25
Oreailurus jacobita	4000	C	65.6	11.6[a]	2,4	1,20,33
Puma concolor	67,500	C	247.7	0.51	2,4,5,6,7	1,4,11,20,25
Artiodactyla						
Cervidae						
Hippocamelus antisensis	68,600	H	3.6	1.1[a]	1,2	1,33
Hippocamelus bisulcus	70,000	H	54.7	0.81	4,5,6,7	1,11,20,25,33
Pudu puda	9750	H	178.9	15	5,6	1,25,33
Camelidae						
Lama guanicoe	120,000	H	130.5	0.51	1,2,4,7	1,4,11,20,27,33
Vicugna vicugna	45,000	H	56.3	3.5	2	1,4,20,33
Rodentia						
Muridae						
Akodon albiventer	21.8	O	52.3	394	2	18,19,33
Akodon lanosus	25	O	20.9	725.6[a]	6,7	11,33,35
Akodon longipilis	37.5	O	340.6	676.8	3,4,5,6,7	4,16,20,22,23,26,33,35
Akodon olivaceus	28	O	498.4	1862.6	1,3,4,5,6,7	4,8,12,22,23,25,26,35
Akodon sanborni	25.9	O	42.2	778.8	5,6	12,21,22,23,25,26,32,35
Akodon xanthorhinus	26.5	O	85.9	3950	6,7	25,30,32,35
Akodon hershkovitzi	29.5	O	12.7	634[a]	6,7	1,30,33
Akodon markhami	30	O	6.3	625.4[a]	6	1,33
Andinomys edax	49.9	H	8.6	398[a]	1,2	18,32,33
Auliscomys micropus	72.7	FG	335.9	463.5	3,4,5,6,7	4,21,22,23,25,26,33,35
Auliscomys boliviensis	54.6	FG	14	153	2	19,32,33
Auliscomys sublimis	38.5	H	42.2	510.3[a]	2	1,33,35
Calomys lepidus	16.9	H	60.2	139	2	18,19,33
Chelemys macronyx	73.3	O	145.3	861	4,5,7	4,11,21,22,23,32,33,35
Chelemys megalonyx	50.8	O	138.3	407[a]	3,7	11,16,25,32,33
Chroeomys andinus	20.1	O	170.3	261	2,4,3	18,19,33
Chinchillula sahamae	139.5	H	9.4	178.7[a]	2	20,32,33

(Table continued overleaf)

Appendix (*continued*)

Species	Weight (g)	Diet	G. Range in Chile (thousand of km^2)	Density (ind/km^2)	Ecoregion	Source
Eligmodontia morgani	16.5	O	48.4	195	4,7	1,11,20,33
Eligmodontia puerulus	28.5	FG	119.5	272	1,2	1,19,20,33,35
Euneomys mordax	82	H	29.7	275.6[a]	4	1,31,34,35
Euneomys chinchilloides	84.7	O	78.9	50	4,6,7	1,25,31,34,35
Euneomys petersoni	83	H	31.7	272.8[a]	7	11,31,34
Galenomys garleppi	59.3	H	3.9	358.9[a]	2	20,33
Geoxus valdivianus	29.7	I	175.8	502.5	4,5,6,7	4,21,22,23,25,32,35
Irenomys tarsalis	43.9	FG	119.5	490.9	5	4,21,22,23,25,26,32,35
Neotomys ebriosus	57.9	H	17.2	56	2	18,32,33
Oligoryzomys longicaudatus	27.8	FG	336.7	589.5	3,5,6	4,6,25,26,32,33,35
Oligoryzomys magellanicus	28	O	90.6	661.5[a]	6	6,35
Phyllotis darwini	57.5	O	102.3	4705	1,3,5	4,8,25,26,35,36
Phyllotis magister	68.5	O	39	506	1,2	18,19,32,33
Phyllotis osgoodi	45.1	H	7.8	448.6[a]	2	1,33
Phyllotis xanthopygus	57.6	O	224.2	320	1,2,4,6,7	19,35,36
Reithrodon auritus	80.2	H	104.7	368.6	4,6,7	4,11,13,25,32,33,35
Caviidae						
Cavia tschudii	275	H	6.9	102.8[a]	1	1,32,33
Galea musteloides	225.7	H	21.1	3500	2	1,20,33
Microcavia australis	286.1	H	61.7	2415	7	25,26,32,33,35
Microcavia niata	255.2	H	3.9	109.2[a]	2	17,18
Chinchillidae						
Chinchilla brevicaudata	500	H	85.9	63.1[a]	2	20,32,33
Chinchilla lanigera	435.5	H	32	770	3	10,20,33
Lagidium peruanum	1220	H	3.9	30.5[a]	2	33
Lagidium viscacia	1540	H	196.1	25.2[a]	1,2,3,4,5	1,18,20,33
Lagidium wolffsohni	2682	H	7.8	16.1[a]	7	11,33
Myocastoridae						
Myocastor coypus	4193	H	169.5	1355	3,5,6,7	3,20,25,27,32,33
Octodontidae						
Aconaemys fuscus	128.6	H	67.2	550	4,5	2,7,21,25,33,35
Aconaemys sagei	135.3	H	3.9	183.2[a]	4	2,7,21,33
Octodon bridgesi	92.5	H	53.9	1450	3,4,5	2,21,24,35
Octodon degus	215	H	83.6	11,424	3	2,4,8,26,35
Octodon lunatus	233	H	56.3	220	3	2,5,35
Octodontomys gliroides	158	H	15.6	83	1,2	2,18,19,32,33
Spalacopus cyanus	100.9	H	51.6	232.7[a]	1,3,4	2,32,33,35
Ctenomydae						
Ctenomys fulvus	360.3	H	60.2	82.5[a]	12	1,32,33,35
Ctenomys magellanicus	258.9	H	63.3	108[a]	7	1,11,32,33,35
Ctenomys maulinus	164	H	21.9	156.6[a]	4	25,33
Ctenomys opimus	361.5	H	29.7	247	2	32,33
Ctenomys coyhaiquensis	140	H	3.9	178.2[a]	7	13,15
Abrocomidae						
Abrocoma bennetti	250.5	H	91.4	83.3	3	8,20,26,32,33,35
Abrocoma cinerea	250	H	46.1	17	1,2	20,32,35

Ecoregions: 1, C. Atacama Desert; 2, Puna; 3, Matorral; 4, Andean Steppe; 5, Valdivian Forest; 6, Subpolar *Nothofagus* forest; 7, Patagonian Steppe. Diet: H, Herbivore; O, Omnivore; C, Carnivore; I, Insectivore; F-G, Frugivore-Granivore. Sources: 1, Contreras (1998), 2, Contreras et al. (1987); 3, Wood et al. (1992); 4, Damuth (1994); 5, Glanz (1977); 6, Gallardo and Palma (1990); 7, Gallardo and Reise (1992); 8, Jaksic et al. (1993); 9, Medel et al. (1990); 10, Jiménez et al. (1992); 11, Johnson et al. (1990); 12, Kelt (1993); 13, Kelt (1994); 14, Kelt and Martínez (1989); 15, Kelt and Gallardo (1994); 16, Mann (1978); 17, Marquet et al. (1993a); 18, Marquet et al. (1993b); 19, Marquet (unpubl. data); 20, Miller and Rottmann (1976); 21, Meserve and Jaksic (1991); 22, Meserve et al. (1991a); 23, Meserve et al. (1991b); 24, Muñoz et al. (1990); 25, Murúa (1995); 26, O'Connell (1986); 27, Ortega and Franklin (1995); 28, Palma (1995); 29, Patterson and Gallardo (1987); 30, Patterson et al. (1984); 31, Pearson and Christie (1991); 32, Pine et al. (1979); 33, Redford and Eisenberg (1992); 34, Reise and Gallardo (1990); 35, Reise and Venegas (1987); 36, Walker et al. (1991); 37, Jiménez (1993); 38, Jiménez et al. (1995); 39, Jiménez (unpubl. data); 40, Medel and Jaksic (1988).

[a] Species whose density value was estimated.

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