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Differences in two species-at-risk classification schemes for North American mammals

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Short Title: Extinction Risk in Mammals

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Abstract

Several classification systems are used to rank species' extinction risk. Assessments from two of these, IUCN and NatureServe, are often used to inform prioritisation of conservation resources and management strategies. However, despite their widespread use, they have rarely been compared. No research has assessed rank concordance specifically for mammals, while factors increasing the chance of mismatches between systems have not been investigated. In this study, consistency of IUCN/NatureServe extinction risk categorisation is compared for 409 classified extant American and Canadian mammals. Taxonomic bias in between-system mismatches is then analysed, and common ecological factors associated with mismatches are also identified. There was a significant positive correlation between IUCN and NatureServe ranks, although this was not strong (r_s = 0.504). Agreement was good for non-threatened categories: 97% of species classified as non-threatened by one system were classified likewise by the other. However, there was considerable discord in threatened categories, with 40% of species classified as threatened by one system and non-threatened by the other. In 89% of such cases, this was due to higher ranking by NatureServe, suggesting that this system is more conservative. Mismatches were identified for 102 of the 373 species with exact rankings on both systems (27%), and these were biased taxonomically with significantly more mismatches for Cetacea and fewer for Rodentia. Mismatches were more common for species with longer gestation periods, fewer offspring per year, and longer life expectancies (all traits associated with K-strategist species), as well as for species in higher trophic levels. Many mismatched species also had fragmented ranges and/or uncertain data. Recognition that IUCN and NatureServe ranks are not synonymous is essential. Assessments should be viewed as complementary and dual results should be used to inform species management. The need for more detailed population demographic data to improve extinction risk calculations should also be addressed.

Keywords

Conservation Triage, Extinction Risk, IUCN, NatureServe, Species Management

Ever since the realisation that conservation resources (money, time, space and expertise) are not infinite, and indeed that demand for action is always likely to be higher than possible supply, biologists have been devising criteria by which to prioritise where conservation is most needed. This is effectively a system of triage – assessing the need for, and the likely benefits of, action in a given situation – and is considered a sound conservation decision-making strategy (Sapir et al., 2003; Bottril et al., 2008).

Many different criteria can be used within a conservation triage system. Some are based upon biology, for example, prioritisation of endemic species, (International Council for Bird Preservation, 1992), keystone species (Mills et al., 1993), or species that are evolutionarily distinct (Redding and Mooers, 2006; Isaac et al., 2007). Others are centred round encouraging public support and funding, for example the prioritisation of flagship species (Dietz et al., 1994; Leader-Williams and Dublin, 2000), or the use of a focal umbrella species to protect multiple co-occurring species (Roberge and Angelstam, 2004). Although all these systems have merit, it is prioritisation of species and habitats based upon their rarity and perceived threat status that has become standard practice for conservation scientists (Mace and Collar, 2002). Indeed, determining which species are thriving and which are rare or declining is seen by many as the single most crucial factor in targeting conservation resources appropriately (Mace et al., 2008).

Rarity-based classification systems have been devised using proxies for extinction risk, such as population size and range size, as well as temporal trends in these parameters. Two well-recognised species-at-risk systems, which both rank species based on their perceived risk of extinction, are the International Union for the Conservation of Nature red list (protocol developed in 1994 and revised substantially in 2001), and the NatureServe conservation status list (initiated in the 1980s, and which now operates at global, national and sub-national spatial scales) (IUCN 1994, 2001; NatureServe, 2011). Although these systems are superficially similar, sharing the same aim (quantification of extinction risk), comprising five categories of risk (from 'secure' to 'critical'), and having similar data requirements (Regan et al., 2005), they use completely different approaches. The IUCN system is a rule-based approach, whereby a species is assigned to a threat category if it meets the quantitative threshold for at least one criterion (Mace et al., 2008). A Population Viability Analysis (PVA) is also calculated for each species to determine, based on species-specific traits, the probability of extinction in the following 100 years. Conversely, the NatureServe approach uses a point-scoring calculator system, whereby a conservation status rank is assigned by assessing multiple factors (e.g. change in population and change in range) (NatureServe, 2011). Both systems have been shown to be useful in predicting actual extinctions in a blind retrospective analysis: extinct species were typically placed in higher risk categories than the extant species with which they were paired (Keith et al., 2004).

Although neither of these systems was devised to allocate conservation resources *per se*, but instead to categorise extinction risk (Possingham et al., 2002), conservation priorities are often informed by apparent vulnerability to extinction (Master, 1991). Accordingly, species-at-risk systems can, and should, provide valuable data to inform species management decisions (Rodrigues et al., 2006). However, despite species-at-risk classification systems being widely (if not always correctly) used to inform legislative protection, and the fact that vital management decisions are made using their results, there have been comparatively few quantitative comparisons between them. Mehlman et al. (2004) compared the systems for North American avifauna using IUCN categories before these were substantially modified (Mace et al., 2008), and the then-current NatureServe categories. No correlation statistics were produced, but between-system visual comparisons showed discordance, especially in the intermediate categories. Two other studies, O'Grady et al. (2004) and Regan et al. (2005), have been conducted to explore the variability in species assessments under both systems. The former used IUCN and NatureServe protocols to categorise 55 species (identical data for each); while the latter asked 18 assessors to categorise 13 species, again on the basis of identical information, to compare inter-observer variability in assessment. In both cases there was some agreement but notable differences were also found, again primarily in the intermediate categories. These three studies have provided valuable insight into how IUCN and NatureServe systems correlate, and the potential for inter-observer variability to occur in their application. However, they were undertaken either using now-outdated versions of the systems in question (Mehlman et al. 2004) or using data from at least six years ago and small sample sizes (O'Grady et al., 2004; Regan et al., 2005). Moreover, there was no consideration of potential taxonomic bias in the agreement between systems, nor any consideration of any ecological or biogeographical characteristics usually associated with species ranked discordantly on the different systems. A new study, using the revised versions of both the IUCN and NatureServe systems, would be useful to establish the current level of concordance between these systems and address these additional questions.

Here I compare the consistency of extinction risk level, as derived by IUCN and NatureServe, for the 409 extant mammal species that occur in the US and Canada and that are classified using both systems. Mammals were chosen on the basis that no previous study has been undertaken specifically on this class, despite the fact that it has one of the highest proportions of described species classified as threatened (25%; Schipper et al., 2008). As both systems represent a valid method of classification (Mehlman et al., 2004), the purpose of this is not to discuss the accuracy of the systems, nor to claim that a difference in the rankings means that one system is "better" or "worse" than the other. Instead, the aims are to understand these differences, quantify occasions where perceived extinction risk differs between systems, and, for the first time, analyse what type of species are most frequently the subject of mismatches between classification systems, both with regard to mammalian order (to establish whether there is a taxonomic bias), and in terms of ecological/biogeographical characteristics.

Methods

Datasets

Data giving the global NatureServe and global IUCN classifications for all mammal species currently extant in any part of the United States of America and Canada were obtained from NatureServe Explorer (http://www.natureserve.org/explorer) in January 2011. To avoid the risk of IUCN data being mis-transcribed or outdated, these data were cross-validated with the IUCN red list (http://www.iucnredlist.org/). The data classifications were temporally consistent (NatureServe version = August 2010; IUCN version = 2010.4 (available October 2010)). The final sample size was 409 species after species ranked on only one classification scheme (i.e. those with an IUCN ranking of DD (Data Deficient) or a NatureServe ranking of GU (Unrankable) or GNR (Not Ranked)) had been discounted. *Monachus tropicalis* (Gray, 1850) and *Neovison macrodon* (Prentis, 1903), which were both listed as extinct (EX) on the IUCN list and presumed extinct (GX) on the NatureServe list, were also excluded, as were sub-species. Data were coded so that 1 = least threatened and 5 = most threatened (Table 1). In total, 36 species had dual NatureServe ranks (always consecutive categories, for example, G1/G2 or G4/G5). These were given a median (.5) value (e.g. G1/G2 = 4.5; G4/G5 = 1.5).

Relationship between variables

Correlations between the extinction risk ranks from IUCN and NatureServe were calculated on a per-species basis, for both the whole dataset and for specific subsets (e.g. mammal orders) using Spearman Rank correlations as per O'Grady et al. (2004) and Regan et al. (2005). This accounted for the non-parametric (ranking) nature of the data.

Mismatches

Mismatches in extinction risk status were defined as differences between the ranking level of any specific species with relation to the IUCN and NatureServe systems; for example, if a species was listed as endangered (4) on the IUCN list but vulnerable (3) on the NatureServe list (see Table 1). Serious mismatches were defined as situations where the IUCN/NatureServe rankings were more than two categories adrift; for example critically endangered (IUCN = 5) and vulnerable (NatureServe = 3). Absolute mismatches were recorded when a species was considered threatened in one system and non-threatened in the other (Table 1). Species with dual NatureServe ranks were excluded from mismatch analysis except when neither NatureServe category matched the IUCN category (e.g. G4/G5 and EN). The number of mismatches was recorded for each mammal order and the nature of these mismatches (NatureServe>IUCN or IUCN>NatureServe) was identified.

Taxonomic bias

Mammals were classified as being within one of five mammalian orders: Cetacea (whales, dolphins and porpoises; n = 21), Chiroptera (bats; n = 42), Rodentia (rodents; n = 208), Carnivora (carnivores; n = 52) and Other (mainly dominated by ungulates, shrews, and rabbits/hares; n = 86) as per NatureServe (2011). To establish any taxonomic bias in mismatches, the frequency within each order was compared to what would be expected if all orders were equally susceptible to mismatches using chi-square analyses (expected values being calculated on the basis of the number of species within each order).

Ecological variables associated with mismatches

Data on the ecological traits of the species analysed in this paper were extracted from the PanTHERIA database (Jones et al., 2009). Thirteen of the 50+ ecological and biogeographic variables were selected *a priori* from this list for further analysis in relation to mismatch likelihood. The variables selected were those that described key traits such as trophic level, size, dispersal and sociality, as well as several variables that could be used to describe the position of a species on the r-K strategist continuum (e.g. longevity and number of offspring per year) and the generalist-specialist continuum (e.g. habitat breadth). Analysis was undertaken in two ways depending on the data type. For ecological traits that were measured on a continuous ratio scale (e.g. size, range area etc.), single predictor binary logistic regression was used with the presence/absence of a mismatch as the dependent variable (see Table 3 for the full list of variables and Jones et al. (2009) for details of how these were calculated). Bonferroni corrections were applied in order to allow for family-wise error as a result of multiple analyses being conducted on non-independent data. For the three ecological traits that were nominal (trophic level, habitat breadth, and period of activity (nocturnal, diurnal or mixed/crepuscular)), chi-square analysis was used with the mismatch frequencies as the observed data analysed against expected data generated using the proportion of all species in each category (the same method as used for the taxonomic bias).

In addition to these quantitative analyses, a more qualitative approach was taken by reading through the NatureServe profiles for all mismatched species and identifying recurring themes in a tabular format with species-specific examples. It is recognised that this is a subjective analysis, possibly based on ad-hoc information, but it complements the more formal statistical analysis and is justified as a preliminary analysis for the generation of research questions and hypotheses.

Results

Correlation between systems

Perceived extinction risk, as determined by the IUCN and NatureServe systems, was significantly positively correlated (r_s = 0.504, d.f. = 389, P < 0.001), although this was not particularly strong (Fig. 1). The correlation coefficients varied according to mammal order, with the most concordance for Carnivora and the least for Chiroptera; all correlations were significant (Table 2). A full list of the 102 mismatched species is given in the appendix.

Species classified as non-threatened using both systems

Overall, 97% of species that were classified as non-threatened (Table 1; Fig. 2) in one system were also classified as non-threatened by the other system. Of the species in the lowest NatureServe category (G5), 99.6% were also in the lowest IUCN category (LC), such that there was complete agreement between the systems (Fig. 2a). Of the species in the second lowest NatureServe category (G4), 98.6% were also classified as non-threatened by IUCN. Interestingly, however, a greater number of these G4 species were in the lowest IUCN category (LC; 89.9%), rather than the second lowest category (NT; 8.7%) as would be expected. When comparing IUCN rankings with those of NatureServe (Fig. 2b), a similar pattern emerged: 78% of LC species were placed in G5, with complete agreement between systems, while a further 19% were classified in G4. Of the species in the second lowest IUCN category, 50% were in the second lowest NatureServe category (G4).

Species classified as threatened by both systems

In total, 60% of species classified as threatened in one of the two systems were also classified as threatened by the other system. However, even for these species, the actual categories varied considerably (Fig. 2), with exact agreement in just 21% of cases. The proportion of mismatches between specific threat categories was fairly evenly distributed as regards which system gave the more critical ranking (NatureServe>IUCN = 55%; IUCN>NatureServe = 45%). With regard to the most severe category of each system, all species listed as CR by IUCN were also in either G1 or G2, but species listed as G1 were in VU, EN or CR (and indeed more G1 species were listed as EN than any other category).

Species classified as non-threatened by one system and threatened by the other

In total, 40% of species classified as threatened in one system were classified as non-threatened by the other. This equated to an absolute mismatch in extinction risk classification for 8.6% of species. In the vast majority of cases (88.9%), absolute mismatches were due to species being classed as threatened by NatureServe and not threatened by IUCN, a contrast from the fairly even split for mismatches within the threat categories (see above). A few species in the lowest IUCN threat category were placed in the threatened categories of NatureServe (G3 = 2%; G4 = 1%). For the species placed in the NT category of IUCN (i.e. near threatened, but not currently so), half were classified as threatened according to NatureServe. Most surprisingly, 10% of all species with the highest NatureServe threat level (G1) were classed as non-threatened (NT) by the IUCN.

Taxonomic bias

In total, there were IUCN/NatureServe mismatches for 102 species out of 373 (27.2%), serious mismatches for 28 species (7.5%), and absolute mismatches, which resulted in species being considered threatened by one system and non-threatened by the other, for 32 species (8.6%).

Chi-square analysis demonstrated that overall mismatch frequencies were not in accordance with the underlying species order distributions (χ^2 = 23.168, *d.f.* = 4, P < 0.001), with three times more mismatches for Cetacea than would have been expected and fewer mismatches for Rodentia (Table 2). Conversely, there was no taxonomic bias for serious mismatches (χ^2 = 4.226, *d.f.* = 4, P = 0.376), nor for the number of absolute mismatches (χ^2 = 7.418, *d.f.* = 4, P = 0.115) (Table 2).

Ecological variables associated with mismatches

Single predictor binary logistic regression revealed significant associations between mismatch occurrence and: (1) gestation period (positive); (2) number of offspring per annum (negative); and (3) maximum longevity (positive) (Table 3). These individual variables all had high R^2 values (0.171, 0.096 and 0.187, respectively) when compared to a mean R^2 for the non-significant predictors of 0.027, and increased the percentage of correct classification above that which would be possible by chance (Table 3).

Chi-square analysis demonstrated that mismatch frequencies were also related to trophic level (χ^2 = 6.255, *d.f.* = 2, P = 0.044), with more mismatches for species in the highest (third) trophic level than would have been expected given the undertaking data distribution (43% of mismatched species were in the highest trophic level category, whereas only 30% would have been expected to be so). There was no bias in the number of mismatches on the basis of habitat breadth (χ^2 = 1.045, *d.f.* = 2, P = 0.593) or whether a species was diurnal, nocturnal, or mixed/crepuscular (χ^2 = 2.138, *d.f.* = 2, P = 0.343).

When considering species profiles qualitatively, the species most prone to mismatches, regardless of mammalian order and the ecological traits discussed above, were generally those that had fragmented ranges, that differed in abundance throughout their range, or that had a substantial number of potential (but not current) threats. Another commonly-occurring issue for mismatched species was a lack of suitable and/or recent data, which meant that population, temporal changes in population or the success of conservation action were not certain (Table 4).

Discussion

There is an overall correlation between the two species-at-risk classification systems evaluated, however, the relationship is not strong (r_s = 0.504), with the correlation for some orders being even weaker (e.g. Chiroptera r_s = 0.484). The overall correlation coefficient calculated here is substantially lower than that calculated by O'Grady et al. (2004) for 55 species from a variety of taxa (r_s = 0.690). As both studies examined IUCN and NatureServe data, this could indicate that agreement between these systems is particularly poor for mammals, or that agreement is lower between the current versions of the systems (this study) than previously (although it should also be noted that the sample sizes differ substantially, which might influence their direct comparability). It is also likely that some of this difference can be explained by this study utilising original rankings of IUCN and NatureServe, rather than identical information collected by one individual to classify rankings for both systems from scratch (O'Grady et al., 2004). Given that inter-observer variability can substantially confound results (e.g. Regan et al., 2005), it is possible that eliminating this source of error elevated the perceived agreement found in O'Grady's study beyond that which is typical. As conservationists would usually use the published IUCN/NatureServe rankings when planning species conservation priorities and management strategies, rather than re-analysing the data and calculating these independently, this is concerning.

Previous research (Mehlman et al., 2004; Regan et al., 2005) has found considerable agreement between extinction risk calculation systems at the extremes of both scales (i.e. species that are very secure or critically endangered) and most of the disagreement in species classifications occurred in the intermediate categories. However, for the North American mammals studied here, while agreement is very good at the secure end of the spectrum (LC/G5), there is considerable disagreement at the endangered end. Just 30% of species in the highest (most endangered) NatureServe category are in the highest IUCN category, with 75% of those in the highest IUCN category being in the highest NatureServe category. This compares unfavourably with 65% and 100%, respectively, for North American birds (Mehlman et al., 2004). As expected, there was also considerable discord in intermediate categories, particularly VU and G2. Most worryingly, 40% of species classified as threatened by one system are classified as not threatened by the other, meaning that an absolute mismatch is evident for 8.6% of all North American extant mammals, compared with just 3.7% for North American birds (Mehlman et al., 2004).

Mismatches within the threatened categories were not consistently because one system ranked species more highly than the other: the higher category was given by NatureServe on 55% of occasions and by the IUCN on the remaining 45% of occasions. However, absolute mismatches almost always (88.9% of occasions) occurred due to a high NatureServe rank relative to the IUCN rank. This indicates that the NatureServe system is consistently more precautionary, a view also supported by the fact that more species were placed in a threatened NatureServe category (G1-G3) than in a threatened IUCN category (VU-CR) (12% and 8%, respectively). Again this is similar to the pattern for North American birds (7.3% and 6.6%, respectively) (Mehlman et al., 2004). Given that both systems compared here are global in scope (NatureServe global (G) ranks were used here rather than national (N) or sub-national (S) ranks; see methods), it is unlikely that the more precautionary character of NatureServe is due to differences in geographic coverage or focus.

Taxonomic Bias

Mismatches occur in all mammalian orders, but they are statistically more prevalent for Cetacea, and less prevalent for Rodentia, than would be expected given the underlying data distribution. A greater propensity for mismatches for cetaceans might reflect the fact that poor knowledge of population sizes and uncertainty in population trends is more prevalent for marine mammals than for terrestrial ones, both generally and in North America (Schipper et al., 2008). Given that uncertainty in data is one of the key factors highlighted in Table 4 as being associated with species mismatches, this seems likely. It is also worth noting that 33% of Cetacea were excluded from analysis here as they had an IUCN rank of DD (Data Deficient), as compared to <4% for all other (predominantly terrestrial) orders, which again suggests greater uncertainty in the marine environment.

Ecological variables associated with mismatches

Mismatches are more likely for species with longer gestation periods, fewer offspring per year and longer life expectancies. These are key ecological traits that differentiate species on the r-K strategist continuum (MacArthur and Wilson, 1967; Pianka, 1970), and, taken together, these results all indicate that K strategist species are more prone to mismatches than r strategist species. It is also worth noting that marine mammals generally tend towards the K-selection end of the continuum (Estes, 1979) (in this dataset, species in this order have, on average, longer gestation periods, lower numbers of offspring per annum, and longer life expectancies, when compared to other orders). This suggests that the higher number of mismatches for cetaceans and K-strategists might be self-reinforcing. The increase in mismatches at higher tropic levels might also link to there being proportionally more species that are K-selected in higher trophic levels than in lower ones.

Implications

The IUCN and NatureServe ranking systems share a common aim: the identification of species at risk from extinction. However, the assessments differ in terms of methods and, certainly in the case of North American mammals, agreement between the two systems is not high. Recognition that the two systems are not synonymous is essential so that results from both can: (1) be considered on their own merits and; (2) allow them to become complementary. It is, therefore, suggested that both the IUCN and NatureServe assessments are used simultaneously whenever it is necessary to calculate extinction risk, together with any other regionally- and/or taxonomically-specific systems that may be appropriate (e.g. US Fish and Wildlife Service (USFWS), Florida Fish & Game (FF&G), Partners in Flight (PIF) and Birds of Conservation Concern (BoCC) (Andelman et al., 2004, Panjabi et al., 2005, Eaton et al., 2009)). This is particularly true when the assessment of extinction risk influences key conservation and management decisions, including prioritisation of funding and resources, since it is vital that these decisions are as informed as possible.

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Table 1: IUCN and NatureServe categories and their ranking as used here for comparison purposes

IUCN Categories	NatureServe Categories	Rank
*CR – Critically Endangered	*G1 – Critically Imperilled	5
*EN – Endangered	*G2 – Imperilled	4
*VU - Vulnerable	*G3 – Vulnerable	3
NT – Near Threatened	G4 – Apparently Secure	2
LC – Least Concern (Unthreatened)	G5 – Secure	1

* Species listed in these categories are regarded as threatened.

Table 2: Agreement between IUCN and NatureServe extinction risk rankings using Spearman Rank correlation. For mismatch definitions and details of sample size differences, please see methods. Due to rounding, the percentages in the mismatch columns do not always sum to exactly 100.

Mammalian	Correlations			Mismatches			
Order	R_s	N	P	Sample Size	Total[a]	Serious	Absolute
All	0.504	409	<0.001	373	102	28	32
Cetacea	0.742	21	<0.001	16 (4.3%)	12 (11.8%)	1 (3.6%)	1 (3.2%)
Chiroptera	0.484	42	0.001	36 (9.7%)	14 (13.7%)	5 (17.9%)	6 (18.8%)
Carnivora	0.737	52	<0.001	49 (13.1%)	16 (15.7%)	3 (10.7%)	5 (15.6%)
Rodentia	0.612	208	<0.001	193 (51.7%)	37 (36.3%)	10 (35.7%)	10 (31.3%)
Other	0.438	86	<0.001	79 (21.2%)	23 (22.5%)	9 (32.1%)	10 (31.3%)

[a] significant taxonomic bias in mismatches on the basis of Chi-square analysis of frequency distributions.

Table 3: Single predictor binary logistic regression results for occurrence of extinction risk mismatches between NatureServe and IUCN (no = 0; yes = 1) in relation to 10 ecological and biogeographical traits (trait data from Jones et al., 2009); bolded entries are significant. Significance values remain unchanged following Bonferroni corrections to allow for family-wise error due to multiple analyses being conducted on non-independent data (significant tests remain significant at $P < 0.01$, non-significant tests remain non-significant at $P > 0.910$).

Variable	**N**	**B**	**Wald**	**Cox and Snell R^2**	**P**	**% Correct**	**% Points Above Chance**
Body mass (g)	293	0	2.067	0.058	0.151	73.4	2.1
Dispersal (age in days)	47	0.001	1.495	0.031	0.222	68.1	0.0
Gestation (days)	**203**	**0.009**	**33.689**	**0.171**	**<0.001**	**84.2**	**3.9**
Home range (km^2)	153	0	0.075	0.001	0.784	86.9	0.0
Offspring (pa)	**181**	**-0.179**	**12.351**	**0.096**	**<0.001**	**76.2**	**6.0**
Maximum longevity (months)	**145**	**0.005**	**18.418**	**0.187**	**<0.001**	**79.3**	**4.0**
Population density (n/ km^2)	164	0	0.467	0.003	0.495	84.4	1.0
Social group size	65	0.172	2.863	0.086	0.091	76.4	2.7
Range size (km^2)	265	0	2.411	0.012	0.120	75.8	0.0
Range (average latitude)	265	0.001	0.008	0	0.928	75.8	0.0

Table 4: Common themes from NatureServe profiles of species that were mismatched with regard extinction risk between NatureServe and IUCN systems.

Characteristics	Examples	IUCN/NatureServe classifications
Species that are highly specialised, often with a restricted range	Texas kangaroo rat (*Dipodomys elator*)	VU/G2*
Species with a highly discontinuous or fragmented range, especially where isolated populations are at, or below, the estimated Minimum Viable Population (MVP) level	Utah prairie dog (*Cynomys parvidens*)	EN/G1*
	Desert pocket gopher (*Geomys arenarius*)	NT/G3*
	Eastern small-footed myotis (*Myotis leibii*)	LC/G3**
Species that are abundant in some parts of the range but that are rare in others	Round-tailed muskrat (*Neofiber alleni*)	LC/G3**
Species that have differing population trends in different parts of their range	Steller sea lion (*Eumetopias jubatus*)	EN/G3*
	Swift fox (*Vulpes velox*)	LC/G3**
Species that do not have any part of their range free from potential (though not current) threats, or where threats are largely unknown	Spotted bat (*Euderma maculatum*)	LC/G4*
	Arizona shrew (*Sorex arizonae*)	LC/G3**
Species whose population dynamics are not well known, at least in parts of its range	Wolverine (*Gulo gulo*)	LC/G4*
	White-sided jackrabbit (*Lepus callotis*)	NT/G3*
	Mexican long-nosed bat (*Leptonycteris nivalis*)	EN/G3*
Species subject to recent conservation intervention, the long-term success of which is still unclear	Washington ground squirrel (*Spermophilus washingtoni*)	NT/G2**
Species with populations that are currently stable or increasing, but only due to intensive management	Sea otter (*Enhydra lutris*)	EN/G4**

396 * = mismatch (one category adrift between systems)

** = serious mismatch (more than one category adrift between systems)

Figure 1: Correlation between IUCN and NatureServe ranks for all 373 extant North American mammal species classified with a single rank on the IUCN and NatureServe systems (for definitions of rank order, see Table 1). The diameter of the circle indicates the relative percentage of species at each intersection point (larger diameter = higher percentage).

Figure 2: Correspondence between IUCN and NatureServe ranks showing: (a) percentage of species in each IUCN category by NatureServe rank; and (b) percentage of each species in each NatureServe category by IUCN rank.

Appendix

Order	Scientific Name	Common Name	IUCN	NatureServe
Cetacea	*Balaena mysticetus*	Bowhead	LC	G3
Cetacea	*Balaenoptera borealis*	Sei Whale	EN	G3
Cetacea	*Balaenoptera musculus*	Blue Whale	EN	G3G4
Cetacea	*Balaenoptera physalus*	Fin Whale	EN	G3G4
Cetacea	*Eschrichtius robustus*	Gray Whale	LC	G4
Cetacea	*Eubalaena glacialis*	North Atlantic Right Whale	EN	G1
Cetacea	*Eubalaena japonica*	North Pacific Right Whale	EN	G1
Cetacea	*Lagenorhynchus acutus*	Atlantic White-sided Dolphin	LC	G4
Cetacea	*Lagenorhynchus albirostris*	White-beaked Dolphin	LC	G4
Cetacea	*Lissodelphis borealis*	Northern Right Whale Dolphin	LC	G4
Cetacea	*Megaptera novaeangliae*	Humpback Whale	LC	G4
Cetacea	*Peponocephala electra*	Melon-headed Whale	LC	G4
Carnivora	*Arctocephalus townsendi*	Guadalupe Fur Seal	NT	G1
Carnivora	*Canis lupus*	Gray Wolf	LC	G4
Carnivora	*Conepatus leuconotus*	American Hog-nosed Skunk	LC	G4
Carnivora	*Cystophora cristata*	Hooded Seal	VU	G4G5
Carnivora	*Enhydra lutris*	Sea Otter	EN	G4
Carnivora	*Eumetopias jubatus*	Steller Sea Lion	EN	G3
Carnivora	*Gulo gulo*	Wolverine	LC	G4
Carnivora	*Leopardus pardalis*	Ocelot	LC	G4
Carnivora	*Monachus schauinslandi*	Hawaiian Monk Seal	CR	G2
Carnivora	*Mustela nigripes*	Black-footed Ferret	EN	G1
Carnivora	*Odobenus rosmarus*	Walrus	LC	G4
Carnivora	*Panthera onca*	Jaguar	NT	G3
Carnivora	*Puma yagouaroundi*	Jaguarundi	LC	G4
Carnivora	*Ursus arctos*	Brown Bear	LC	G4
Carnivora	*Vulpes macrotis*	Kit Fox	LC	G4
Carnivora	*Vulpes velox*	Swift Fox	LC	G3
Chiroptera	*Corynorhinus rafinesquii*	Rafinesque's Big-eared Bat	LC	G3G4
Chiroptera	*Corynorhinus townsendii*	Townsend's Big-eared Bat	LC	G4
Chiroptera	*Euderma maculatum*	Spotted Bat	LC	G4
Chiroptera	*Eumops underwoodi*	Underwood's Bonneted Bat	LC	G4
Chiroptera	*Idionycteris phyllotis*	Allen's Big-eared Bat	LC	G3G4
Chiroptera	*Leptonycteris nivalis*	Mexican Long-nosed Bat	EN	G3
Chiroptera	*Macrotus californicus*	Californian Leaf-nosed Bat	LC	G4
Chiroptera	*Mormoops megalophylla*	Peters's Ghost-faced Bat	LC	G4
Chiroptera	*Myotis austroriparius*	Southeastern Myotis	LC	G3G4
Chiroptera	*Myotis grisescens*	Gray Myotis	NT	G3
Chiroptera	*Myotis keenii*	Keen's Myotis	LC	G2G3
Chiroptera	*Myotis leibii*	Eastern Small-footed Myotis	LC	G3
Chiroptera	*Myotis septentrionalis*	Northern Myotis	LC	G4
Chiroptera	*Nyctinomops femorosaccus*	Pocketed Free-tailed Bat	LC	G4
Rodentia	*Cynomys ludovicianus*	Black-tailed Prairie Dog	LC	G4
Rodentia	*Cynomys parvidens*	Utah Prairie Dog	EN	G1

Rodentia	*Dicrostonyx richardsoni*	Richardson's Collared Lemming	LC	G4
Rodentia	*Dipodomys agilis*	Agile Kangaroo Rat	LC	G3G4
Rodentia	*Dipodomys californicus*	California Kangaroo Rat	LC	G4
Rodentia	*Dipodomys compactus*	Gulf Coast Kangaroo Rat	LC	G4
Rodentia	*Dipodomys elator*	Texas Kangaroo Rat	VU	G2
Rodentia	*Dipodomys venustus*	Narrow-faced Kangaroo Rat	LC	G4
Rodentia	*Geomys arenarius*	Desert Pocket Gopher	NT	G3
Rodentia	*Geomys personatus*	Texas Pocket Gopher	LC	G4
Rodentia	*Geomys streckeri*	Strecker's Pocket Gopher	VU	G1
Rodentia	*Geomys texensis*	Central Texas Pocket Gopher	LC	G2
Rodentia	*Marmota broweri*	Alaska Marmot	LC	G4
Rodentia	*Marmota olympus*	Olympic Marmot	LC	G3G4
Rodentia	*Microdipodops megacephalus*	Dark Kangaroo Mouse	LC	G4
Rodentia	*Microdipodops pallidus*	Pale Kangaroo Mouse	LC	G3
Rodentia	*Microtus breweri*	Beach Vole	VU	G1
Rodentia	*Microtus canicaudus*	Gray-tailed Vole	LC	G4
Rodentia	*Microtus chrotorrhinus*	Rock Vole	LC	G4
Rodentia	*Neofiber alleni*	Round-tailed Muskrat	LC	G3
Rodentia	*Neotamias alpinus*	Alpine Chipmunk	LC	G4
Rodentia	*Neotamias canipes*	Gray-footed Chipmunk	LC	G4
Rodentia	*Neotamias cinereicollis*	Gray-collared Chipmunk	LC	G4
Rodentia	*Neotamias obscurus*	California Chipmunk	LC	G4
Rodentia	*Neotamias ochrogenys*	Yellow-cheeked Chipmunk	LC	G4
Rodentia	*Neotamias panamintinus*	Panamint Chipmunk	LC	G4
Rodentia	*Neotamias siskiyou*	Siskiyou Chipmunk	LC	G4
Rodentia	*Neotamias speciosus*	Lodgepole Chipmunk	LC	G4
Rodentia	*Perognathus inornatus*	San Joaquin Pocket Mouse	LC	G4
Rodentia	*Peromyscus gratus*	Saxicoline Deermouse	LC	G4
Rodentia	*Spermophilus canus*	Merriam's Ground Squirrel	LC	G4
Rodentia	*Spermophilus washingtoni*	Washington Ground Squirrel	NT	G2
Rodentia	*Synaptomys borealis*	Northern Bog Lemming	LC	G4
Rodentia	*Thomomys bulbivorus*	Camas Pocket Gopher	LC	G3G4
Rodentia	*Thomomys clusius*	Wyoming Pocket Gopher	LC	G2
Rodentia	*Thomomys idahoensis*	Idaho Pocket Gopher	LC	G4
Rodentia	*Thomomys mazama*	Western Pocket Gopher	LC	G4
Other	*Ammotragus lervia*	Barbary Sheep	VU	G5
Other	*Axis axis*	Chital	LC	G4
Other	*Boselaphus tragocamelus*	Nilgai	LC	G3G4
Other	*Brachylagus idahoensis*	Pygmy Rabbit	LC	G4
Other	*Cervus nippon*	Sika	LC	G4
Other	*Lepus callotis*	White-sided Jackrabbit	NT	G3
Other	*Lepus othus*	Alaskan Hare	LC	G3G4
Other	*Oryx gazella*	Gemsbok	LC	G4
Other	*Ovibos moschatus*	Muskox	LC	G4
Other	*Ovis canadensis*	Bighorn Sheep	LC	G4
Other	*Sorex arizonae*	Arizona Shrew	LC	G3
Other	*Sorex bairdi*	Baird's Shrew	LC	G4
Other	*Sorex bendirii*	Marsh Shrew	LC	G4
Other	*Sorex dispar*	Long-tailed Shrew	LC	G4

Other	*Sorex gaspensis*	Gaspé Shrew	LC	G3Q
Other	*Sorex jacksoni*	St. Lawrence Island Shrew	LC	G3
Other	*Sorex lyelli*	Mt. Lyell Shrew	LC	G2G3
Other	*Sorex nanus*	Dwarf Shrew	LC	G4
Other	*Sorex pacificus*	Pacific Shrew	LC	G3G4
Other	*Sorex preblei*	Preble's Shrew	LC	G4
Other	*Sorex pribilofensis*	Pribilof Island Shrew	EN	G3
Other	*Sorex tenellus*	Inyo Shrew	LC	G3G4
Other	*Tragelaphus strepsiceros*	Greater Kudu	LC	G4