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Classifying Threatened Species: Means and Ends [and Discussion]

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Classifying threatened species: means and ends

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SUMMARY

Threatened species lists are widely consulted as sources of information on the conservation status of species. However, their application to planning for conservation is limited because they have not been developed systematically, and because the criteria used to judge extinction risk are subjective. Recently, new proposals have been made to increase the broader usefulness of these lists, and some elements of these proposals are reviewed here. Apart from indicating the geographical and taxonomic groups containing most threatened species, these lists can provide other kinds of information. Some data from threatened species classifications using quantitative criteria provide a new method for estimating extinction rates in a variety of vertebrate taxa. This analysis suggests that over the next 100 years, the extinction rate could be as high as 15–20% in these groups. These values are comparable to those based upon extrapolations from species-area curves. However, allocating threatened species categories is only a first step towards developing rational systems for setting conservation priorities. These systems will need to consider a quite different set of variables, including those for incorporating species conservation priorities in area-based planning.

1. INTRODUCTION: THE ROLE OF THREATENED SPECIES LISTS

Over the next several decades, action will need to be taken towards preserving the many species now facing extinction. In this paper, I review the role that categorizing species according to their perceived risk of extinction can play, and outline some of the practical advantages and disadvantages of this approach.

Threatened species lists are produced most commonly in the Red Lists and Red Data Books of the IUCN – the World Conservation Union. These were formally established in the early 1960s (Scott *et al.* 1987) and, although their size, format and style has evolved since that time, the basic concept of providing readily assimilated information to focus attention on the plight of endangered species remains. The Red Data Book concept has been very successful, and there are now many regional, national and taxonomic lists based upon it (Burton 1984; Fitter & Fitter 1987).

Increasingly the lists have become used for more than just raising awareness and have been applied to setting priorities for species conservation. In this context it is important that the process for categorizing species is objective, standardized and equally applicable across broad taxonomic groups whose basic biology and life histories differ fundamentally. The current categorization system is perceived to have problems in this regard, and recently steps have been taken towards revising methods used to categorize species (Fitter & Fitter 1987; Mace & Lande 1991; Master 1991; Mace *et al.* 1992).

A broad spectrum of concerns have been raised over the development of systems to categorize species according to their risk of extinction. These range from the relationship between species against ecosystem level conservation to the consequences of such lists for poorly known or even undescribed species (see Diamond 1989; Mace 1994*a*,*b*). However, the value of the lists is clear both from their widespread use and from the interest that has been generated by them (Fitter & Fitter 1987).

2. SYSTEMS FOR CLASSIFYING SPECIES ACCORDING TO RISK OF EXTINCTION

With this background to the role of threatened species categories, a review of a range of recently published systems is presented in table 1. This is not a comprehensive review; rather, it aims to provide a representative sample of recent systems, and complements a full review by Munton (1987).

Most of these systems are based around existing IUCN definitions, usually with some amendments. Many regional threatened species lists in U.S.A. use the Endangered Species Act definitions as a basis (see also Munton 1987). In addition, the classification of rarity by Rabinowitz (1981) has been used, and two more recent proposals based on quantitative criteria (Mace & Lande 1991; Mace *et al.* 1992) have been adopted for some well-studied taxonomic groups. Others have been developed entirely independently (table 1).

The main conclusion from the information presented in table 1 is that threatened species listings measure a number of characteristics that are not

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Table 1. *Characteristics used in definitions of threatened species categories*

(In column 3: IUCN, IUCN criteria; M-L, Mace & Lande (1991); dIUCN, Mace *et al.* (1992); ESA, Endangered Species Act (Rohlf 1989); Rab., Rabinowitz *et al.* (1986); TNC, Master (1991). In columns 4–15: '+', characteristic scored in threatened species categorization system; N, numerical guidelines given; –, not relevant. In column 16: reference numbers: 1, IUCN (1972); 2, IUCN (1978); 3, IUCN (1979); 4, IUCN (1977); 5, IUCN (1988); 6, IUCN (1990); 7, IUCN (1985); 8, IUCN (1991); 9, Collar & Stuart (1985); 10, IUCN (1982); 11, IUCN (1983); 12, Green (1992); 13, Osborne (1994); 14, TISTR (1991); 15, Terwilliger (1990); 16, Ingelof *et al.* (1993); 17, Oates (1986); 18, Eudey (1987); 19, Master (1991); 20, Briggs & Leigh (1988); 21, Reed (1992); 22, Shirt (1987); 23, Bratton (1991).)

1. taxon	2. region	3. basis	4. in danger of extinction	5. will become endangered	6. population size small	7. small range or number of sites	8. commercial or specific threats	9. recovered from threat	10. protection status	11. declining	12. declined but not threatened	13. suspected threatened but no data	14. not threatened	15. endemic to region	16. references
vertebrates	global	IUCN	+	+	+	+		+						–	1–4
primates	Africa	IUCN	+	+	+	+						+	+	–	5
lemurs	Madagascar and Comores	IUCN	+	+	+	+						+		–	6
swallowtail butterflies	global	IUCN	+	+	+	+		+				+		–	7
dolphins, porpoises and whales	global	IUCN	+	+	N	+						+		–	8
birds	Africa	IUCN	+	+	+	+		+		+	+			–	9
amphibia and reptiles	global	IUCN	+	+	+	+		+				+		–	10
invertebrates	global	IUCN	+	+	+	+	+					+		–	11
waterfowl	global	M-L			N		+			+				–	12
cycads	global	dIUCN			N					+			+	–	13
all	Thailand		+		+	+			+					+	14
all	Virginia, U.S.A.	ESA	+	+	+	+	+								15
all	Baltic	IUCN	+	+	+	+					+	+			16
primates	Africa and Asia		+	+	N	+							+		17,18
all	Americas	TNC	+		+	N							+		19
plants	Australia		+	+	N	+			+			+			20
migrant birds	neotropics	Rab			+	+	(+)								21
insects	Britain	IUCN			+	N		+		+				+	22
other invertebrates	Britain	IUCN			+	N		+		+		+		+	23

directly related to the extinction risk. Sometimes this is done overtly by separating these into distinct categories; for example, 'Out of Danger' in the IUCN system does not qualify a species for threatened status. But many characteristics that could lead to listing in a threatened category do not necessarily reflect threat. For example, a restricted geographical distribution is sufficient to qualify a species for inclusion in the IUCN category 'Rare', and the category 'Insufficiently Known' includes species that are 'suspected' to belong in one of the threatened categories, but about which there is little information. These categories are therefore measuring multiple characteristics of species, many of which may have a bearing on planning for their conservation, but not necessarily reflecting their risk of extinction.

All systems reviewed use small population size specifically in defining threatened status, although only a minority (5 of 19) present any quantitative guidelines. The effect of turning from qualitative to quantitative definitions may be significant. In less well known groups it is likely that the number in the threatened category will decline, because of the difficulties of applying quantitative criteria to poorly known species. However, in general the application of quantitative criteria to well studied vertebrate groups has led to an increase in the number of species listed as threatened (Seal *et al.* 1993; Mace 1994*a*). Some consequences are exemplified in the categorizations made by Green (1992) for waterfowl and Osborne (1994) for cycads. Both these groups had previously been classified by the IUCN criteria. In both cases there was an increase in the number of taxa (species or subspecies) listed as threatened (61 to 74 for cycads; 36 to 52 for waterfowl). However, this was not simply due to a shifting of boundaries; there was quite a substantial change in the set of taxa listed as threatened. In the cycads, 15 taxa were threatened according to IUCN definitions but not threatened by the quantitative criteria, and 20 were threatened according to quantitative criteria but not threatened by IUCN definitions. The equivalent figures for waterfowl are 27 and 11 taxa, respectively.

Almost all of the systems also use small range size or number of sites explicitly, usually in a definition for a category such as 'Rare'. Rarity can take a variety of forms, and the framework suggested by Rabinowitz (1981) and Rabinowitz *et al.* (1986) is useful for considering extinction risk in relation to different forms of rarity (Thomas & Mallorie 1985; Rabinowitz *et al.* 1986). Species with small population sizes, restricted ranges and narrow habitat specializations are always considered especially vulnerable, and the classically 'common' species with abundant populations over large geographical ranges and broad habitat types are always considered 'safe'. However, there is little consensus about the relative risks faced by taxa classified into the other six forms of rarity (see Reed 1992; Kattan 1992). There are also two practical problems which limit the use of these classifications at a general level. One is that each of these three variables is actually a continuum, and some arbitrary decisions have to be made about where the cut-off points lie. Secondly, there are always difficulties and compromises in the measurement of habitat specificity.

Several criteria relate in some way to management or its consequences, and this is a difficult area in the categorization of threat. There are demands to have species listed as threatened, even if past or current management has led to a stable or increasing population. This is especially the case where a threatened species classification translates directly into legislation or into species protection. A logical consequence is that dependence upon protection would need to be a criterion for endangered status, and no species under management would ever leave the threatened species lists. However, an aim of conservation action should be to reduce the number of species listed as threatened. It would seem to be more logical to differentiate between threatened forms (i.e. those that are thought to be currently at high risk of extinction) and species dependent upon continuing management. This is not quite the same as the intent of the IUCN category 'Out of Danger' (now rarely used), which was used for cases where a species was previously listed but had recovered, and is therefore an historical rather than a continuing status assessment.

It seems surprising that population declines have not more commonly played a role in the listing of species, yet only 5 of the 19 systems incorporate this in their definitions. Fundamentally, an endangered species in one that is showing or is expected to show evidence of decline. Combined with small population size or small range sizes, population decline seems intuitively to be a more reliable indicator of risk than do either of these two characteristics alone.

In many published lists of threatened species, a large number are classified as being suspected threatened but with insufficient data to make a definite judgement. The category 'Insufficiently Known' in the IUCN definitions is specifically for this situation, and it has been widely applied. The classification is not useful for conservation planning as it is unclear where these species sit in relation to those that can be said definitively to have a high or moderate extinction risk, and it does not indicate anything about the kind of information that is required or that which is available. Conversely, taking species that are poorly known out of the threatened species lists altogether may prejudice their survival simply on the basis that we know little about them. In addition, species may be classified as insufficiently known for a variety of reasons. They may be at risk because their only known habitat is being lost but so little is known about their status that it is impossible to say whether they are endangered, vulnerable or rare. Alternatively they may be known only from historical records from a remote site rarely visited by naturalists. Their actual status could be anything from extinct to common. Finally, Cooke (1991) gives a reasoned argument for a very broad application of the 'Insufficiently Known' category in the categorization of cetaceans. He argues that this category should be applied to species that are not definitely known not to satisfy the criteria for any of the other threatened categories, and that the only situation where this could be true would be where all or most populations are known not to be declining. This requires good information, and among the cetaceans only one species (the grey whale) qualifies. Therefore, all others that are not classified in another threatened category are classified as insufficiently known. If this logic were applied to many groups, the vast majority of species would be classified in this category.

Ideally, three things could help resolve the problem of how to treat poorly known species. First, the criteria for the categories could explicitly include risks derived from habitat change or loss affecting many species, for which direct information on status is lacking. Second, classifications could be accompanied by some statement about the extent and reliability of information used to make the evaluation. Third, there could be a separate classification for species for which additional information is required before extinction risk can be evaluated. This would be distinct from the Red List and would more effectively highlight those species in need of survey or study, as opposed to those known to need protection. However, these measures alone do not solve the problem of how to best cope with the extent of our ignorance.

Few systems have explicitly included 'Not Threatened' in their categorization scheme, and, as discussed earlier, this has led to uncertainty about the status of those species not listed. There seems to be no logical reason why this cannot be included, except for a reluctance to publish an assessment that could so easily and disastrously be proven wrong. If confidence can be placed in the criteria for threatened categories and a taxon can be shown not to qualify, then this should be stated. In fact, very often the information is so poor that the taxon cannot be shown not to qualify, which is a manifestation of the problem of how best deal with poorly known forms (see above). Undoubtedly there should be a 'Not Threatened' or similarly named category, as there should be a category for taxa that have not even been evaluated against the definitions.

Finally, a number of regional studies have included categories that reflect the distribution of taxa inside and outside the region, especially to indicate those that are endemics, or whose major populations are found locally. This is generally more useful for conservation planning than assessing extinction risk (see below).

3. THE PROPOSED NEW IUCN CRITERIA

The development of new IUCN categories is now well under way (Mace *et al.* 1992). These new definitions and criteria are still under active review and refinement, but an outline is presented here.

The threatened species classification scheme falls within a larger scheme which will be applicable to all species and which will indicate whether a species has been assessed, whether there was sufficient information to categorize according to threat level and, if so, whether the species was felt to be threatened, not threatened, or in need of continuing conservation management. The threat categories are defined only in terms of extinction risk, with decreasing threat levels over increasing time periods (Mace & Lande 1991). There are three threat categories ('Critical', 'Endangered' and 'Vulnerable') which fall on a continuum, and a fourth category ('Susceptible') which is reserved for taxa that do not qualify for any of the higher threat categories but which, as a consequence of restricted distributions, are continually at risk of extinction. A series of quantitative criteria are provided for the categories of 'Critical', 'Endangered' and 'Vulnerable', and to qualify for listing a species has to satisfy one of these. The five criteria are measures of: (i) observed, inferred or projected decline rates; (ii) small populations that are either single or fragmented associated with an observed, inferred or projected decline; (iii) small geographical range areas or extents associated with an observed, inferred or projected decline; (iv) very small population sizes; and (v) a quantitative analysis predicting a given extinction risk within a specified time period (see Mace *et al.* 1992).

The system was designed to be appropriate for all macro-fauna and flora, and, although early drafts presented separate criteria for different major taxa, it became clear that with this approach species that had unusual life histories for their own major taxa might be judged by inappropriate criteria. It was therefore more conservative to consolidate criteria for diverse major life styles into a single set of criteria, and allow meeting any one to qualify the species for listing at that level. Depending on the perspective of the classifier, some of the criteria therefore may appear inappropriate or even absurd. However, under this system what matters is whether any of the criteria are met, not whether all are appropriate. The current review procedure has aimed to investigate whether application of the proposed criteria to diverse taxonomic groups indicates false listings, and so far it has not appeared necessary to alter this structure, although there are concerns about some of quantitative levels.

4. ESTIMATING EXTINCTION RATES FROM THREATENED SPECIES LISTS

Because most lists are based on non-quantitative criteria and definitions, they cannot be used to make predictions about extinction rates. Smith *et al.* (1993*a*) have recently analysed the changes in species lists in IUCN Red Lists published between 1986 and 1990 to make some estimates of extinction risk. However, as they make clear, for most taxa these will be underestimates because of incomplete evaluations (see above). However, once the definitions for categories, and the criteria that determine listing under them, become quantitative, it will be possible to use these lists to make estimates of future extinction rates. A major caveat here is that listing of a taxon under a threat category does not necessarily constitute a prediction, because the very fact that it has been

Table 2. *Extinction rates for vertebrate species calculated from threatened species categories*

	Critical (%)	Endangered (%)	Vulnerable (%)	*n*	estimated extinct in 100 years (%)	estimated years to 50% extinction
reptilia						
Boidae	5.9	12	35	17	17	365
Varanidae	0	3.5	34	29	6	1168
Iguanidae	4.0	8.0	56	25	15	428
birds						
Anseriformes	4.6	8.3	20	109	16	404
Gruidae	17	0	50	6	19	335
Psittaciformes	7.3	8.3	24	302	15	421
Bucerotidae	10	30	40	10	34	166
mammals						
Marsupialia	3.4	11	34	179	14	453
Canidae	5.9	12	21	34	16	403
Cervidae	29	29	21	14	50	101

perceived to be in trouble, and placed on a Red List, should encourage effective conservation actions that reduce the extinction risk.

At this early stage in their development it is not appropriate to use the new draft IUCN criteria in this context. However, the quantitative definitions and criteria proposed by Mace & Lande (1991) have now been applied to a range of vertebrate taxa, mainly through activities of various IUCN Species Survival Commission Specialist Groups (Seal *et al.* 1993; Mace 1994). For a range of higher taxa, species and subspecies have been classified as 'Critical' (50% risk of extinction in 5 years or 2 generations, whichever is longer), 'Endangered' (20% risk of extinction in 20 years or 10 generations, whichever is longer), 'Vulnerable' (10% risk of extinction in 100 years) or 'Safe'. These assessments can be used to make some very rough estimates of future extinction rates, using a similar methodology to Smith *et al.* (1993*a*), except that here the analysis is based upon evaluations of extinction risks across all extant members of certain higher taxa, instead of upon recorded extinctions. The data presented in table 2 are compilations from Mace (1994*a*) and show the percentage of species in ten vertebrate taxa placed in each of the threatened categories 'Critical', 'Endangered' and 'Vulnerable'. Only species-level estimates are presented here, although in most taxa (not marsupials and canids) many classifications were made at subspecific level, and their parent taxa not then evaluated. The categories are defined by single risk and time points, but for the purpose of this analysis all were standardized to 100 years by fitting exponential extinction functions.

On this basis, no 'Critical' taxa and only about 33% of 'Endangered' taxa are expected to persist for 100 years. Applying these survival rates across threatened classes gives the percentage of species in each group that are expected to be extinct in 100 years time (table 2). These percentages range from 6% to 50%. The 50% figure for cervids may be rather inflated because most cervid taxa were evaluated at the subspecific level, where the proportion of threatened forms was lower (see Mace 1994*a*). These values are similar to estimates of species extinction rates derived from species-area curves. Recent estimates for tropical forest species lie between 10% and 40% loss over 100 years (Reid 1992).

From these values, the characteristic extinction time, or estimated time to 50% extinction, can be calculated, and these values are shown in the final column of table 2. They range from about 100 to over 1000 years, but for most taxa are around 300–400 years. These time periods are much shorter than those calculated from recorded extinctions and are at the very low end of estimates based on transitions of species through existing Red List categories (Smith *et al.* 1993*a*). Smith *et al.* (1993*a*) note that their estimates were likely to be low due to under-recording, and the results of this analysis, where recording is complete, bear this out.

There are, however, several reasons why these estimates might be rather too short. First, the definitions for these categories are based upon time periods measured in years or generations, and the generations measure will be used whenever species generation lengths exceed 2.5 years (for 'Critical') or 2 years (for 'Endangered'). Most of the taxa in table 2 have generation lengths substantially longer than this. Second, there could be a bias from only using taxa that were not evaluated at subspecific level, as these might commonly be restricted range forms or island endemics, which would then be expected to have a

Table 3. *Vertebrate extinction rates at different taxonomic levels and adjusted for generation length*

level	Critical (%)	Endangered (%)	Vulnerable (%)	*n*	estimated extinct in 100 years (%)		estimated years to 50% extinction	
					low	high	low	high
species	5.9	9.7	28	725	15	11	433	613
subspecies	8.3	16	28	554	22	14	281	447

higher extinction risk. In table 3 the average values across all species and subspecies in this data set are analysed, and the effects of increasing generation length to 6 years (a rough estimate of a median) is shown. In fact, on average, the subspecies data give higher extinction risks (22% expected extinct in 100 years compared with 16% for species), and have a characteristic extinction time of 281 instead of 433 years. Increasing generation length increases the characteristic extinction time for species from 433 years to 613, and for subspecies from 281 to 447.

These estimates are still very crude. The criteria used to classify taxa into the categories are only very approximate (Mace & Lande 1991) and have not been, and probably cannot be, generally validated. Further, the procedure used to standardize them all to a 100 year period is simplistic. Also, the taxa were assessed in workshop sessions, and are inevitably based upon very little information. There is undoubtedly a strong inclination to be highly conservative in making estimates under these conditions, especially as in most cases there was no option to place taxa into an 'Insufficiently Known' category, although some remained unclassified (Seal *et al.* 1993). They may therefore represent worst case assessments. Finally, the results should not be generalized across other vertebrate taxa because the groups so far analysed probably represent higher order taxa that most clearly contain large numbers of threatened forms. No such analysis has yet been performed on, for example, rodents or passerine birds, and the outcome might be quite different.

The results are, however, interesting as they generally corroborate analyses made on species extinction rates from entirely independent methods: from species-area curves (Reid 1992) and from analyses of rates of movement of species through categories in existing Red Lists (Smith *et al.* 1993*a*).

5. CONCLUSIONS

Interesting as the analysis of extinction rates is, the compilation of threatened species lists should not necessarily be an end in itself. In terms of conservation action aimed at limiting the extinction rate, the categories can be used in systems for setting conservation priorities, and determining appropriate short and longer term activities. The analysis of species data for setting conservation priorities is an important developing area, and one that has so far received rather little analysis. It is, however, one of the most significant applications of threatened species categories.

The development of more objective and systematic methods for evaluating the threat status of species will have many implications for conservation action. At one level, it will allow a better general evaluation of the extent of the current species extinction spasm, and the regional and taxonomic biases. At a practical level, however, it will allow the incorporation of threat levels into the rational planning of conservation actions.

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Discussion

W. Kunin (*NERC Centre for Population Biology, Silwood College, U.K.*). One point raised several times, most notably by Dr S. Pimm, has been the importance of population variability, alongside population size, in determining the probability of extinctions. Has population variability entered into calculations of threat categories?

G. M. Mace. Yes, in the new draft IUCN criteria, variability is included in two ways that make listing of taxa with variable populations more likely.