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doi:10.1890/11.WB.025

No safety in numbers

Clements *et al.* (*Front Ecol Environ* 2011; **9[9]**: 521–525) proposed a single metric that describes a "species' ability to forestall extinction" (referred to by the acronym "SAFE") as a "scientifically defendable rule of thumb for when complete demographic data are unavailable" to rank the relative threat status of a species. SAFE is calculated on a logarithmic scale and reflects the difference between a species' current population size and 5000, the estimate for a universal minimum viable population (MVP) promoted by Traill *et al.* (2010). Clements *et al.* advocated SAFE as a useful tool for triage to allocate resources in conservation, and as a measure of population viability that would be more easily understood by the public than the IUCN Red List categories (Mace *et al.* 2008). We believe that SAFE is not a useful metric to guide conservation planning for three main reasons.

First, a universal MVP of 5000 individuals, regardless of taxon or circumstance, is poorly supported (Flather *et al.* 2011). Studies promoting this benchmark overlooked substantial uncertainty in standardized MVP estimates that span several orders of magnitude for the same species, suggesting 5000 is likely to be a poor estimate for *any* specific population. Methods used to standardize MVP estimates across disparate studies were not robust (Flather *et al.* 2011). MVP estimates depend critically on the environmental context of a population and on the way that context interacts with decisions made in the population modeling process.

Second, theory and practice strongly suggest that metrics other than population size are equally or more important in determining a population's viability (Lande 1993; Caughley 1994; Flather *et al.* 2011). Viability of a species is a composite of many characteristics, such as the mean and variance of its growth rate, the number and connectivity of its populations, its range size and trends, and its life history, rather than simply its distance from 5000. Clements *et al.* implicitly acknowledge this by comparing the performance of their SAFE metric versus range change (both independent variables) to the IUCN Criteria (the dependent variable or "truth"), which is based on a complex series of factors combined to assess status. The ordinal logistic regressions only accounted for 6% of the deviance.

Third, SAFE offers little to inform the conservation of threatened species. Populations can only be conserved if the factors that cause them to decline are identified and those threats are ameliorated. Obtaining a reliable estimate of population size for comparison to the unreliable MVP estimate of 5000 suggests that sufficient information on species' ecology, habitat, and current threats is likely to exist to inform conservation. Triage decisions based on population size alone are pointless, ignoring circumstance, trends, taxonomic uniqueness, desirability, and other important factors that affect such decisions.

Population size is one indicator of population viability, much like a patient's body temperature is one indicator of health. However, there is no single number that represents a healthy temperature for all people, because time of day and many other circumstances affect it. Moreover, physicians do not use body temperature alone to determine a living patient's prognosis, make triage decisions, or diagnose cause of illness.

The way forward to develop measures that assist conservation planning is not through oversimplification. Classification systems, such as those developed by IUCN and others, are useful for ranking the degree of threat because they incorporate a wide range of information related to population viability. They do so because no single population characteristic is sufficient to describe population viability. Conservation planning advances when it combines comprehensive measures of population viability with knowledge of how these factors relate to threats, an understanding of social desires, and estimates of the cost of recovery.

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doi:10.1890/11.WB.026

The SAFE index should not be used for prioritization

Clements *et al.* (*Front Ecol Environ* 2011; **9[9]**: 521–525) proposed the SAFE index to measure a "species' ability to forestall extinction". However, we believe that this index can, at best, only measure threat – not the ability to forestall extinction. We note and concur with other concerns regarding the index (letters by Akçakaya *et al.* and Beissinger *et al.*, this issue), but focus on the points below for the sake of brevity.

The SAFE index is simply a measure of how far the population size (N) is from the minimum viable population size (MVP). If the MVP were

Of the 95 mammal species we assessed for the SAFE index, 63 are IUCN threat-listed. Of these, 51% are not assessed by the IUCN on population size thresholds at all, and only one assessment is even partially based on PVA. Indeed, based on our recent (July 2011) examination of Critically Endangered, Endangered, or Vulnerable species, not one of 1370 mammal or 1288 bird species relies entirely on criterion E data, and only 4 mammal and no bird assessments include any PVA information. Hence, the assertion that the SAFE index (a measure of distance from MVP) simply reproduces the Red List is demonstrably incorrect. It is debatable to what extent the Red List categories predict real extinction risk (O'Grady *et al.* 2004); regardless, they must largely invoke reductions in geographic range and population size to do so.

(2) SAFE replaces the Red List. Under no circumstances did we assert that the SAFE index should replace the Red List, or that conservation-based prioritization should be based "solely on population size". We clearly called for SAFE to be used in conjunction with the Red List to provide a more heuristic measure of relative species-extinction threat. We agree that assessments made on population size (and their distance to MVP) alone are inadequate to explain all elements of risk – claiming otherwise would be astonishingly naïve (Brook *et al.* 2011). The contribution of SAFE to the existing Red List categories is that, in addition to reflecting susceptibility to stochastic extinction processes, it provides a continuous measure both *among* and *within* risk categories (somewhat analogous to RAMAS software's Red List fuzzy-number categorization method [www.ramas.com/redlist.htm]). This is pertinent given the ambiguous nature of categorical terms like "endangered", "threatened", and "vulnerable" that are often confused by lay persons and used interchangeably or inconsistently in national-level legislation. In a triage context, the choice to invest in conserving particular species can be informed, at least partially, by MVP (Traill *et al.* 2010) and SAFE by indicating how urgently a species requires attention.

(3) SAFE simplifies to population size (N). We incorporated a logarithmic transformation in SAFE to ease interpretability for our "distance from extinction and to MVP" concept across many species, and for standardization purposes. For example, take hypothetical species A and B – comprising 200 and 2 000 000 individuals, respectively – and assume a threshold MVP target of 5000. Even for specialists, explaining the relative risk as "species A is 4800 individuals away from the threshold target", and "species B is 1 995 000 individuals above the threshold" becomes a confusing mix of largely irrelevant numbers and qualifiers. We maintain that it is far easier to infer whether species A is in trouble based on a negative SAFE index (–1.40, in this case), and that species B is at far less risk based on its positive SAFE value (2.60). As we originally stated in our paper, the threshold MVP value need not necessarily be 5000; if one has sufficient data to estimate, for instance, a taxon-specific MVP, then different denominator values could be used for different taxa (Traill *et al.* 2010; Brook *et al.* 2011). This process would act to normalize comparisons of SAFE-based extinction risks among groups (taxa or otherwise) with intrinsically different MVP sizes. Commonly used biodiversity evenness metrics such as Shannon's Index also use logarithms to make large and small sample sizes comparable.

(4) MVP size is not generalizable. Several authors took exception to our concept of a generalizable MVP size for use as a target threshold, based mainly on arguments raised in a recent critique (Flather *et al.* 2011). We have addressed these concerns elsewhere (Brook *et al.* 2011), but summarize our principal defense here. Although MVP does vary among species, the key emergent result is that thousands, and not hundreds, of individuals are needed to minimize the risk of stochastic extinction – this is the essence of the MVP "rule of thumb" (Traill *et al.* 2010). PVAs are unavailable to estimate MVPs for most species, so generalizations are required in most instances. The alternative – to argue that the problem is too intractable and uncertain and that all species are unique – leads nowhere in terms of practical conservation management.

In conclusion, we are surprised that a heuristic concept designed to enhance conservation decision making has evoked such spirited criticisms from the progenitors of the Red List (Akçakaya *et al.*) and other conservation decision-theory specialists (Beissinger *et al.* and McCarthy *et al.*). Putting aside arguments about uncertainty and relative merit, the real test of the SAFE concept's utility will be determined by whether it can contribute usefully to on-the-ground conservation decisions.

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doi:10.1890/11.WB.028