Comment on "Can we Name Earth's Species Before They Go Extinct?"

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Costello *et al.* (Review, 25 January 2013, p. 413) challenged the common view that many species are disappearing before being described. We suggest that their conclusion is overly optimistic because of a limited selection and interpretation of available evidence that tends to overestimate rates of species description and underestimate the number of species on Earth and their current extinction rate.

In an attempt to draw attention to the challenge of describing and monitoring Earth's biodiversity in the face of looming environmental crises, it has been frequently claimed that many species are likely going extinct before being named (*1*–*5*). Costello and colleagues (*6*) challenged this view and suggested that such a worry "result[s] from overestimates of how many species may exist, beliefs that the expertise to describe species is decreasing, and alarmist estimates of extinction rates." We suggest that their conclusions are overly optimistic because of a limited selection and interpretation of the available evidence. We consider each strand of evidence individually.

Are there fewer species? Previous estimates of the number of species on Earth have fallen broadly between 3 and 100 million species [see table 1 in (*3*) and table 1 in (*5*)]. Costello *et al.*'s consensus estimate of 5 ± 3 million species falls at the low end of this range primarily because of the inclusion of two very low values as part of a small sample of estimates. We argue that there is little support for a preferential selection of those two estimates and that a broader review of available estimates will give higher consensus values. One of these studies was derived from extrapolating species description rates and provides perhaps the lowest estimate yet of the total number of species on Earth: 2 million (*7*). The other combined estimates from species description rates, ratios of undescribed species in samples, and expert opinions and put the global number of marine species at 0.7 to 1 million (*8*). The limitations of these methodologies are well known: Modeling rates of species description underpredict true values when using incomplete data [figure 3, K to O, in (*3*)], ratios are highly variable depending on how well the sampled areas have been studied (*9*), and expert opinions have limited empirical basis and considerable subjectivity (*9*, *10*). In turn, a broader consideration of available estimates would have given values above 8 million species even without including controversial hyperdiverse estimates (*6*). For example, the estimates compiled by Scheffers *et al.* (*5*) yield 7.8 to 8.7 million species of animals, 0.29 to 0.39 million plants, and 0.6 to 1.5 million fungi (excluding hyperdiverse estimates), for a total of 8.7 to 10.6 million species (without including protists and prokaryotes). Costello *et al.* also suggested that the fact that the number of species per author is decreasing is an indication that the pool of undescribed species on Earth is getting smaller. However, the fact that ~0.5 million species may be in museum jars awaiting description (*6*) suggests that the downward trend in the number of species per author is unlikely to be due to a shortfall of species to name; another possibility that should also be considered regarding the downward trend in the number of species per author is that there may now be more coauthors per described species.

Is taxonomic effort overestimated? The number of species described each year is a key metric of taxonomic effort for estimating the time it would take to describe the unknown species on Earth. Costello *et al.* suggest that some 18,000 species are described every year, citing work derived mainly from The International Plant Names Index and The Zoological Record (*11*). However, these databases are repositories for nominal species (i.e., all species that have received a name regardless of their current status), and thus their use may err on the side of overestimation when quantifying rates of description of valid species. For instance, we cross-checked all 229,309 species names reported since 2000 in the Zoological Record with authoritative databases such as the Catalog of Life and the World Register of Marine Species and found that only 56,397 were recognized as valid species and 47,395 as synonyms, invalid names, and/or duplicates due to either variations in the names of authors or by also being named as subspecies and/or as subgenera. Unfortunately, 125,517 species names in the Zoological Record could not be matched to authoritative databases and should be considered with caution as several other sources of duplication may exist, including basionyms (i.e., valid species that receive new names to control for homonyms and changes to different taxonomic ranks or positions) and typographical errors. For comparison, the combined record of species from all kingdoms of life in the Catalog of Life, the World Register of Marine Species, and the List of Prokaryotic Names with Standing in Nomenclature indicates that on average ~8000 valid species were described annually from 1990 to 2000 (this period was chosen to avoid the time lag it takes to store species names into these databases).

Are current extinction rates overestimated? Costello *et al.* considered that "realistic" extinction rates likely range between ~0.001% and ~0.1% per year (*6*), which is equivalent to ~50 to ~5000 species going extinct annually, assuming 5 million species on Earth. Although there remains great uncertainty about current extinction rates (*12*, *13*), an assessment of available evidence supports a higher rate. For instance, analysis of the estimates compiled by Stork (*13*), which included estimates derived from species-area relationships (i.e., extinctions induced by deforestation and climate change), Red List category changes, and co-extinctions, showed that the average rate of species extinction was 0.72%

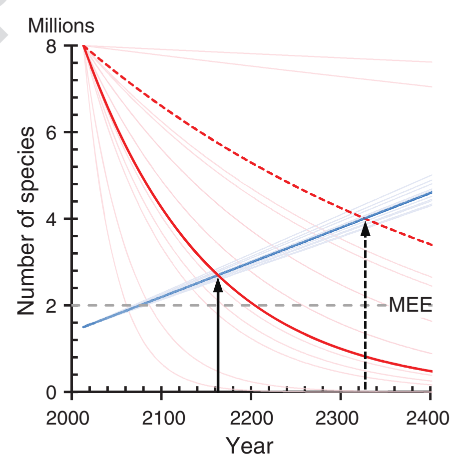

Fig. 1. Contemporary rates and extrapolations of species description (blue lines) and extinction (red lines). Although neither description nor extinction rates will remain constant over time, Costello *et al.*'s (*6*) approach is useful at indicating when all extant species will be described by identifying the year when the trend of described species (on average, 8000 species a year ~~between 1990 and 2000~~, blue line) intercepts with the trend of extinct species (on average, 0.72% a year, solid red line; dotted red line indicates the average rate after removing extinction rates yielded by species-area relationships: 0.22% a year). Individual rates analyzed here are shown in light colors. As reference, the extinction level in the five previous mass extinction events (MEE, >75% of all species going extinct) is indicated with the horizontal gray line.

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per year (~36,000 species a year if there are 5 million species). Only two out of the 15 case studies were as low as the highest "realistic" rate proposed by Costello *et al*. Removing all rates derived from species-area relationships, which are currently debated [(*12*), but see (*14*)], still yields a mean extinction rate of ~0.22% or ~11,000 species a year if there are 5 million species. Although it is true that our current record of extinct species is very low [~800 recorded extinctions by the IUCN (www.iucnredlist.org/about/summary-statistics#Tables_3_4 (*15*)], this number needs to be considered within the context that only ~65,000 species have been assessed to determine their current extinction vulnerability (www.iucnredlist.org/documents/summarystatistics/2012_2_ RL_Stats_Table_1.pdf) and that of those only ~55% have assessments based on complete information [www.iucnredlist.org/about/red-list-overview#expanding_coverage) (*15*)]. This lack of information also accentuates the reluctance to declare species prematurely extinct [due to the skepticism generated when declared-extinct species are rediscovered (*16*)]; thus, for many species it can take years before being declared extinct (*15*, *16*).

Unfortunately, Costello's overarching question—can we name Earth's species before they go extinct?—is very sensitive to changes in the estimates discussed above. For instance, although neither taxonomic effort nor extinction rates will remain constant over time, using the same approach as Costello *et al*. and assuming 8 million species, 8000 species described per year, and a yearly extinction rate of 0.72%—all intermediate values—we estimate that by the year 2164 all extant species will be described, at which point ~5 million species will become extinct (solid black arrow in Fig. 1). If extinction rates are set to 0.22% a year (i.e., the rate after excluding those derived by species-area), by 2327 all extant species would be discovered and ~4 million would be extinct (dashed black arrow in Fig. 1). These values are far less comforting than those of Costello *et al*. (*6*). F1

Although we agree with Costello *et al*. that alarmist overestimates of biodiversity loss are unhelpful, we also contend that underestimating the task ahead and overestimating our capacity to address it could lead to a false sense of confidence. Clearly, multiple sources of uncertainty remain in our knowledge of biodiversity and its rate of loss on Earth; however, the magnitude of the challenge ahead is considerable and should not be underestimated, because the unique diversity of life on our planet and the services it provides to humankind are at stake.

References and Notes

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