ECOLOGY

Estimating the Size of the World's Threatened Flora

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The most commonly cited figure for the fraction of the global flora threatened with extinction—13%—is known to be a serious underestimate, because it does not include a reliable tally of species at risk in the tropical latitudes where most of the world's plants grow (*1*, *2*). Here we estimate the missing tropical data from global patterns of plant endemism. The results suggest that as many as half of the world's plant species may qualify as threatened with extinction under the World Conservation Union (IUCN) classification scheme.

Comprehensive Red Lists for plants are available for only a scattering of tropical countries, making it difficult to assess the true scale of the global conservation crisis for plants. We have approximated the missing tropical data by observing that the number of plant species endemic to a country is a reasonable proxy for the number of globally threatened plant species in that country. In European countries, the former is a strong predictor of the latter ($r = 0.94$, $P < 0.0001$, $n = 21$, counts square-root transformed for normality), and the slope of the raw data is 0.78 (see supplementary data set in Table S1). Similarly, 83% of plant species endemic to the South American country of Ecuador qualify as globally threatened under IUCN criteria (*3*). At the global scale, 91% of the species in the most comprehensive list of threatened plant taxa to date are endemic to a single country (*1*).

Data on national-level endemism in the tropics are far from perfect, but they are consistently better than data on threatened species. We used published and unpublished data on national-level endemism [mostly from (*4*)], currently threatened species [mostly from (*1*)], and land area for 189 countries and territories to generate new estimates of the fraction of the world's flora that may be globally threatened (see supplementary data set in Table S1). Because the total number of plant species on Earth remains a matter of debate, we made separate calculations on the basis of two recent estimates, 310,000 (*5*) and 422,000 (*2*, *6*).

Species endemic to a single country represent 46 to 62% of the world flora. That is likely an overestimate of the global proportion of threatened species, because (i) many temperate countries have accurate tallies of their threatened floras, which are in some cases substantially smaller than their endemic floras (e.g., Australia), (ii) endemics in "biodiversity hot spots" are more likely to qualify as threatened than those elsewhere (*7*), and (iii) species endemic to small countries are more likely to be threatened than species endemic to large countries. Four other calculations of the proportions of threatened plant species are described in Table 1. The results fall in the range 22 to 47%, considerably higher than previous estimates (*1*, *2*).

The vast proportion of potentially threatened tropical taxa (~121,000 species) are endemic to countries in biodiversity hot spots where high floristic diversity and massive habitat loss coincide (*7*). Evaluating the conservation status of these species, adding deserving taxa to the IUCN Red List, and updating their status regularly would provide a relatively inexpensive yardstick to measure the success or failure of conservation efforts in hot spots, while at the same time essentially completing the global database of threatened plants. On the basis of our experience in recent checklist and red book projects in megadiverse Ecuador (*3*, *8*), we estimate the cost of such a project at <$100 per species per year, for an annual budget of <$12.1 million for all hot spots. This would require only 2.4% of the annual hot spots budget proposed by Myers *et al.* (*7*). Only with the species-by-species information generated by such an undertaking will conservationists be able to monitor and prevent the large-scale plant extinctions foreseen to occur in the tropics in this century.

Table 1. Five estimates of the number and proportion of plant species threatened with extinction worldwide. The percentages are calculated by dividing the estimated number of threatened plant species by global floras of 422,000 (*2*, *6*) and 310,000 (*5*) species, respectively.

Estimate	Number of threatened species in each country calculated as:	Number of plant species threatened (proportion of total)
I	The number of species endemic to that country	193,513 (46 to 62%)
II	For tropical countries, the number of endemic species; for temperate countries, the number of currently threatened species	144,282 (34 to 47%)
III	For tropical hot spot countries, the number of endemic species; for other tropical countries, 50% of endemic species; for temperate countries, the number of currently threatened species	141,555 (34 to 46%)
IV	For tropical countries measuring <300,000 km^2, the number of endemic species; for other tropical countries, 50% of endemics; for temperate countries, the number of currently threatened species	94,052 (22 to 30%)
V	For tropical countries in hot spots or measuring <300,000 km^2, number of endemic species; for other tropical countries, 50% of endemics; for temperate countries, number of currently threatened species	141,974 (34 to 45%)

References

1. K. S. Walter, H. J. Gillett, Eds., *1997 IUCN Red List of Threatened Plants* (IUCN, Gland and Cambridge, 1998).
2. D. Bramwell, *Plant Talk* **28**, 32 (2002).
3. R. Valencia, N. Pitman, S. León-Yánez, P. M. Jørgensen, Eds., *Libro Rojo de las Plantas Endémicas del Ecuador 2000* (Pontificia Universidad Católica del Ecuador, Quito, 2000).
4. S. D. Davis, V. H. Heywood, O. Herrera-MacBryde, J. Villa-Lobos, A. C. Hamilton, Eds., *Centres of Plant Diversity: A Guide and Strategy for their Conservation* (World Wildlife Fund, Oxford, 1997).
5. G. T. Prance, *Ann. Mo. Bot. Garden* **87**, 67 (2000).
6. R. Govaerts, *Taxon* **50**, 1085 (2001).
7. N. Myers, R. A. Mittermeier, C. G. Mittermeier, G. A. B. da Fonseca, J. Kent, *Nature* **403**, 853 (2000).
8. P. M. Jørgensen, S. León-Yánez, Eds., *Catalogue of the Vascular Plants of Ecuador* (Missouri Botanical Garden, St. Louis, MO, 1999).

Supporting Online Material

www.sciencemag.org/cgi/content/full/298/5595/989/DC1

Table S1

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