The Numbers of Species: Known and Unknown

As to numbers, collaboration between Kew and the Missouri Botanic Garden created the Global Plant List (www.plantlist.org). This lists 350 700 species of vascular plants, comprising 304 000 flowering plants, 1100 species of gymnosperms, 10 600 species of ferns and lycopsids, and 35 000 species of mosses and liverworts. There are about twice as many synonyms (different names given inadvertently to the same species). Dividing these up between those considered valid species and those that were not, SoWP estimates that, with synonyms resolved, approximately 391 000 named vascular plant species are considered valid. (This is essentially the same as the 400 000 estimated earlier using a similar process [2,3].) The World Checklist of Selected Plant Families (http://apps.kew.org/wcsp/) is being used to analyze the numbers, family by family. Kew and many partners intend this process to lead to a Plants of the World Online Portal, which they consider will allow all names to be unambiguously referred to as an accepted name according to an expert’s opinion. In parallel, a computer-based, collaborative account of all the world’s plants, the World Flora Online, driven by a network of institutions headquartered at the Missouri Botanical Garden, will provide authoritative evaluations of all plant species, with a deadline for completion by 2020. We hope these two efforts will soon become mutually compatible.

How many vascular plant species remain to be named? The rate of description of new species shows that the taxonomic catalog is far from complete. For example, from 1950 to 2000, starting with approximately 70 000 species of monocots, the numbers of newly described species in the World Checklist increased from a couple of hundred per year to over 1000 [4]. An underlying cause was that progressively more researchers were involved in describing species: from approximately 50 to 250 per year worldwide. From 2004 to 2015, SoWP shows that the total number of all new angiosperm species described per year remained almost constant, at 2000. For these 12 years, Australia (1648 species), Brazil (2220), and China (1537) are the top three countries, although Colombia, Ecuador, and Peru combined have a total of 2813 for the same period. Poorly known New Guinea contributes only 334 names, a surprisingly small number compared with the many species that scientists estimate occur there. That is doubtless partly due to the difficulty of reaching remote areas there (Figure 1), but all tropical areas remain relatively poorly studied [5,6].

How many more species remain undiscovered? As the supply of undescribed species falls, one might expect the rate of species description to decline. It has not [3]. Correcting for the increased numbers of researchers describing new species, the adjusted rates of species description decline, allowing statistical models to predict when no more unknown species will remain. These models suggest there will be 15% more species, and, so, a total of, say, 460 000 species of flowering plants [3]. If there are another 70 000 or so plant species to be named, perhaps half of them are already present as specimens in herbaria [7], but many of these are likely to be in groups that are not being studied actively.

How Many Species Are Currently at Risk of Extinction?

How many of the named species does extinction threaten currently? Usefully, SoWP tabulates the various estimates, mostly in the 20–33% range, then plumps for ‘1 in 5’. Their details highlight the complexities. First, the IUCN Red List has only assessed a sample of approximately 22 000 species, of which 7% had insufficient data, while 52% were deemed threatened. SoWP argues that this is too high an estimate for all plants because the Red List emphasizes taxa at particular risk of extinction.
An estimate of 20% is broadly comparable with well-known vertebrate taxa for which one can separately calculate extinction rates directly from following species fates from their year of scientific description [2]. For these vertebrates, human actions are now driving species extinct 1000 times faster than the normal, background rates of extinction. If plants have similar rates of extinction, these would also be 1000 times faster than the rates of plant speciation derived from molecular phylogenies [8].

The tabulations by SoWP show higher percentages of species at risk when one sensibly adds in the predicted numbers of species as-yet unknown to the total of threatened species. They are likely to be rare, which is often why we have not yet found them. Moreover, they are likely to be where the recent discoveries are, which are also places where habitat loss is proceeding rapidly (see above).

The alarming question is whether these as-yet unknown species will survive long enough for us to collect them. To illustrate, Tom Croat and Doug Stevens, two active plant taxonomists at the Missouri Botanical Garden, who have been working and collecting plants, mostly in Latin America, for about a half century each, agree that only a small percentage of the localities where they have collected them still hold natural forest today. Given that so many plant species have small geographical ranges [2], it is likely that, in areas with massive habitat loss, none of their original habitat remains.

**How Many More Species Will Become Threatened in the Future?**

In addition to habitat loss, climate disruption will doom species. Current estimates of how many vary widely [9], in part, because the underlying mechanisms are complex [10]. Some species will be unable to move upwards on mountains rapidly enough to keep within their thermal tolerances. Or, for example, the

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Figure 1. Finding Plants in Remote Places. (A) Those searching for new plant species are a novelty in remote parts of New Guinea. Much of the forests in New Guinea may be gone in 20 years, for example [5]. (B) However, such searches do yield substantial numbers of new species, including these new species of the orchid genus *Corybas* [13]: Clockwise from top left: *Corybas sagittatus*, *Corybas vitiodiapalus*, *Corybas finisterreanus*, and *Corybas huonensis*. Photos reproduced, with permission, from S.P. Lyon.
southern borders of Africa and Australia are rich in endemic plant species and moving south as the climate warms is not an option for many of them. Climate disruption also involves changing fire regimes, the loss of pollinators, increases in herbivores, the changing phenologies of the pollinators and herbivores of a plant, and many other factors.

Of overarching concern is the growth in human populations and consumption. Accordingly, the physical condition of the world is deteriorating rapidly. The Global Footprint Network (www.footprintnetwork.org) estimates that we are using approximately 164% of the world’s sustainable productivity now, up from 70% in 1970. Consequently, higher estimates of future extinction, say, within this century, appear warranted than those based on current conditions. The highest estimates of threat (up to 60%) come from assuming that all species endemic to a country may be at risk because of their presumed small ranges and on-going habitat loss [11], as the conditions just enumerated accelerate. All in all, it seems reasonable to assume that half of all species, most of them unknown at the time of their loss, may disappear within the remainder of this century.

For plants, unlike most other groups of organisms, ex situ preservation is relatively simple [12]. Seed samples gathered from maternal parents, say 20 from a population, will reasonably represent the genetic diversity of the population. With cryopreservation and other special techniques available, practically any plant can be preserved in a seed bank for decades or more. Another option is tissue culture. Plants can of course also be maintained in cultivation, even though it is difficult to maintain sufficient genetic diversity to support a species or even a population that way.

To save them in any way means that we must know that they exist. Given the essential value that plants have for human life, it is clearly well worth finding ways to push as hard as we can to discover missing species and preserve them. For some, it may be their last days in nature.

References

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