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Biodiversity

Extinction by numbers

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How large will be the loss of species through human activities? And over what time period might that loss unfold? Habitat destruction is the leading cause of species extinction. Generally, many of the species found across large areas of a given habitat are represented in smaller areas of it. So habitat loss initially causes few extinctions, then many only as the last remnants of habitat are destroyed. Thus, at current rates of habitat destruction, the peak of extinctions might not occur for decades. But we should not be complacent. On page 853 of this issue, Myers *et al.*[1] document an uneven, highly clumped, distribution of vulnerable species over the world's land surface. Within these 'biodiversity hotspots', habitats are already disproportionately reduced.

Conservatively, there are about seven million species of eukaryote[2] – a definition encompassing most organisms that would be generally recognized as plants or animals but excluding bacteria, for instance. Most of these seven million are animals and about 85% are terrestrial.

Humanity is rapidly destroying habitats that are most species-rich. About two-thirds of all species occur in the tropics, largely in the tropical humid forests[3]. These forests originally covered between 14 million and 18 million square kilometres, depending on the exact definition, and about half of the original area remains[4]. Much of the rain-forest reduction is recent, and clearing now eliminates about 1 million square kilometres every 5 to 10 years[4,5,6]. Burning and selective logging severely damages several times the area that is cleared[5,6].

To convert habitat loss to species loss, the principles of island ecology are applied to the terrestrial 'islands' that remain in a 'sea' of converted land[7]. The relationship between number of species and island area is nonlinear, and from this one can predict how many species should become extinct as the size of the forest islands shrinks. These doomed species do not disappear immediately, however.

How does one go about calculating the rate of species extinctions from habitat fragments? There have been only a few such estimates, but projections based on a species survivorship curve with a half-life of roughly 50 years seem reasonable[8]. Combining the rate of habitat loss, the species-to-area relationship and the survivorship curve gives a crude extinction curve (curve a in Box 1). From this, we would expect that current extinction rates should be modest — on the order of a thousand species per decade, per million species, a figure that matches other estimates[9].

Because the species–area curve is non-linear, the clearing to date of half of the humid forests is predicted to eliminate only 15% of the species that they contain. The time delays before extinction mean that many more species should be 'threatened' than have already become extinct; that is, they are thought likely to become extinct in the wild in the medium-term future. At least 12% of all plants[10] and 11% of all birds[11] come into this category.

Of course, clearing the remaining half of the forests would eliminate the other 85% of species that they contain. The extinction curve should accelerate rapidly to a peak by the middle of the twenty-first century if the rate of forest clearing remains constant. But it will be upon us sooner if that rate is increasing — as seems probable[4,6].

Once the extinction peak has passed, the extinction curve declines into the twenty-second century as species are lost from the remaining fragments of habitat. The relative height of the peak depends critically on the amount of habitat that remains. A value of 5% of remaining habitat (see Table 1 on page 853) would protect about 50% of all the forests' species; smaller percentages would lead to smaller estimates of surviving species.

Modest tinkering with parameters does not alter the 'fewer extinctions now, many more later' feature of the extinction curve (curve a in Box 1). But the calculations of Myers *et al.*[1] do. They show that roughly 30–50% of plant, amphibian, reptile, mammal and bird species occur in 25 hotspots that individually occupy no more than 2% of the ice-free land surface (see the map on page 853). That is, terrestrial species with small geographical ranges are numerous and they have highly clumped distributions. Myers *et al.* exclude the oceans from their analysis. But there, too, fishes and other organisms dependent on coral reefs are simi-larly concentrated[12].

Habitat destruction acts like a cookie cutter stamping out poorly mixed dough[9]. Species found only within the stamped-out area are themselves stamped out. Those found more widely are not. Moreover, species with small ranges are typically scarcer within their ranges than are more widely distributed species, making them yet more vulnerable. Consequently, even random destruction would create centres of extinction that match the concentrations of small-ranged species — the hotspots[9].

Worse, however, Myers *et al*. show that the cookie cutter is not random — it is malevolent. In the 17 tropical forest areas designated as biodiversity hotspots, only 12% of the original primary vegetation remains, compared with about 50% for tropical forests as a whole. Even within those hotspots, the areas richest in endemic plant species — species that are found there, and only there — have proportionately the least remaining vegetation and the smallest areas currently protected.

Applying the species–area relationship to the individual hotspots gives the prediction that 18% of all their species will eventually become extinct if all of the remaining habitats within hotspots were quickly protected (curve c in Box 1). Assuming that the higher-than-average rate of habitat loss in these hot-spots continues for another decade until only the areas currently protected remain (curve b in Box 1), these hotspots would eventually lose about 40% of all their species. All of these projections ignore other effects on biodiversity, such as the possibly adverse impact of global warming, and the introduction of alien species, which is a well-documented cause of extinction of native species.

Unless there is immediate action to salvage the remaining unprotected hotspot areas, the species losses will more than double. There is, however, a glimmer of light in this gloomy picture. High densities of small-ranged species make many species vulnerable to extinction. But equally this pattern allows both minds and budgets to be concentrated on the prevention of nature's untimely end. According to Myers *et al*., these areas constitute only a little more than one million square kilometres. Protecting them is necessary, but not sufficient. Unless the large remaining areas of humid tropical forests are also protected, extinctions of those species that are still wide-ranging should exceed those in the hotspots within a few decades (Box 1).

Show more

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