# THE DODO WENT EXTINCT (AND OTHER ECOLOGICAL MYTHS)

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## ABSTRACT

The scientific consensus is that human impacts are driving species to extinction hundreds to thousands of times faster than expected from the natural background rate. Critics challenge this. Perhaps giving them more credit than they deserve, I examine four concerns. First, that the extinction crisis is not real. It is and high rates of extinction are the rule, not the exception, within well-known taxa. The second criticism dismisses the problem as one restricted just to islands. It is not. Island species have special vulnerabilities, but they are far more locally abundant within their ranges than are continental species with the same range size. There are large numbers of locally rare, continental species with small geographic ranges that are threatened by human impacts. A third criticism notes the few species that became extinct following the clearing of forests from eastern North America in the 19th century, casting doubt upon the relationship between habitat loss and species loss. Analysis of this case history shows that exactly as many species of birds were lost as expected, for the region had very few species to lose. Extensions to species-rich areas such as Southeast Asia and the Atlantic coast of Brazil confirm the expected calibrations with an interesting caveat. Forest losses predict the number of threatened species—those on the verge of extinction—not the number of extinctions. This leads to the final criticism: that there have been too few recent extinctions. The reply is that in these regions the deforestation is more recent and species do not go extinct immediately. Some doomed species can linger for decades—as did the now-extinct species in eastern North America.

*Key words:* deforestation, extinction, species-area curves.

Among scientists there is a broad consensus that species are going extinct in unusual numbers. I will not assemble the evidence for this directly because there are recent reviews (May et al., 1995; Pimm, 2001; Pimm et al., 1995). Rather, I wish to tackle the critics who dispute this consensus. Whatever one thinks of them and those who finance some of them, however one scorns their willingness to ignore volumes of inconvenient facts, the critics persist. They will likely continue to do so while individuals gain financially from short-term environmental destruction. Over the last decade, I have listened to these critics and, perhaps giving them more credit than they deserve, assembled the science to rebut them directly. The synthesis I present here is one based largely on my own work on birds. This is not because it is unique—far from it; there is an abundance of evidence to counter these critics. Rather, it is an attempt to lay out cohesive, linked arguments into a recipe that readers can readily apply to other taxa.

There are four criticisms.

1. The extinction crisis is not real. Rather, it is a "doomsday myth" (Budiansky, 1993). It is the "facts, not the species" that are endangered (Simon & Wildavsky, 1993: A23), the estimates of extinction rates are "strident, inconsistent, and data-free" (Mann & Plummer, 1995). Since the humid tropical forests of the Amazon, Congo and New Guinea, and elsewhere hold the majority of species, their fate is closely tied to the fate of species. Stott (1999) had this to say about them: "'Tropical rain forest' does not exist and never has existed."

2. Those who accept that unusual numbers of extinctions have occurred can still proceed to dismiss their significance. "The dodo went extinct" proclaims the *Oxford English Dictionary.* Most recent extinctions, like the dodo, have been on islands. The implication is that island species are wimpy, naïve, and unsophisticated. Perhaps island species had it coming to them and the urbane, sophisticated species that populate continents may not share their fate.

3. Habitat destruction does not cause extinctions—look at eastern North America, Budiansky (1993) urged. Projections of future high extinction rates such as those by Wilson (1988) and Raven (1988) combine well-documented rates of tropical forest destruction and a model to predict species loss from habitat loss. How good are those predictions? Eastern North America was cleared of its deciduous forests from 1750 to 1900, yet suffered few known extinctions. Critics argue that we simply do not know how to predict the numbers of

species that will be lost as tropical forests disappear.

4. In what is mostly a rehashing of earlier myths, Lomborg (2001) seemed to be asking where are the bodies to prove an extinction crisis? Some early efforts did indeed suggest that there should be lots of extinct species by now. For example, "one seventh to one fifth of all species" extinct within what would now have been the last two decades (Barney, 1980: 328). There are not nearly enough, though to continue the metaphor, there are the requisite number of seriously wounded ones. So are these species really dying off at the expected rate—or are our concerns about them misplaced?

I consider each of these myths in turn.

## 1. THE EXTINCTION CRISIS IS NOT REAL

Has humanity increased extinction rates beyond the background rates expected without our impacts? Those who argue that we have not are claiming that far too few species have gone extinct in the recent past. Where should we look for the extinct species that would reject this assertion?

Pacific islands are the obvious place to start, for they were the planet's last habitable areas to be colonized. Polynesians reached them only within the last 1000 to 4000 years. The evidence of human impact is freshest here. (The evidence of human-caused mass extinctions in Australia, Madagascar, and the Americas grows more compelling each year, however (Flannery, 1999)). Pacific island birds provide unambiguous evidence of massive extinction (Pimm et al., 1994; Steadman, 1995). The bones of many bird species persist into, but not through, archaeological zones showing human presence.

I will consider the Hawaiian islands in detail. We know 43 bird species only from their bones. Yet bird bones are fragile and easily destroyed. We may never find bones of all the now-extinct species, so how many are missing? The bone record would be complete only if all the recent species—those collected or seen in the last two centuries—were also found as bones. The proportion of recent species *also* found as bones estimates how complete the sample of species found *only* as bones is. The proportion is about a half: across the Hawaiian islands, we estimate there are about 40 species missing from the record (Pimm et al., 1994). Add this number to the 43 known species extinctions and the body count rises to 83.

James Cook found the Hawaiian islands in 1778. International trade and colonization followed within a generation. These new people cleared forests and introduced cattle and goats. These destroyed native plants as unprepared for large mammalian herbivores as the birds were for the rats and pigs the Polynesians brought with them on their earlier colonization. Today, our only records of 18 species of birds are the specimens collected by 19th century naturalists. The body count rises to 101.

What remains in the Hawaiian islands today? Pimm et al. (1994) recorded that a dozen species are so rare that there is little hope of saving them. If we cannot find these species, then they probably cannot find each other. A further dozen we can find, but in numbers so small that their future survival is uncertain. Of an estimated 136 species, only 11 survive in numbers that suggest a confident future.

Similar extinctions followed across the Pacific. Over the roughly 1000 years, as the Polynesians colonized the Pacific from New Zealand, north to Hawai'i, and east to Easter Island, they exterminated ~1000 species of birds or ~10% of the world total (Pimm et al., 1994; Curnutt & Pimm, 2001). On some islands, they exterminated all the bird species they encountered.

They extensively cleared lowland forests, especially the drier ones (and used only Stone-Age technology to do so). Birds were not the only victims of these colonizations, incidentally. Of 980 native Hawaiian plants, 84 are extinct and 133 have wild populations of fewer than 100 individuals (Sohmer, 1994). These plant extinctions were the consequence of recent human colonizations. Quite how many plant species the Polynesians exterminated we may never know.

Few species groups leave traces; land snails are one and their losses illustrate the bizarre but extensive devastation that human actions can effect. A predatory snail, *Euglandina rosea*, introduced to many Pacific islands to control another introduced snail, *Achatina fulica*, ate to extinction hundreds of taxa of native *Achatinella* and *Partula* land snails (Hadfield, 1986; WCMC, 1992). (I use the term "taxa" to include recognized geographically distinct populations. Taxonomic uncertainties often raise and sink their specific status. For those that are now extinct we may never resolve the issue.)

Nor are Pacific islands unusual in their species losses. As European explorers moved from their coastal waters from the early 1500s, Mauritius, Rodrigues, and Réunion in the Indian Ocean lost 33 species of birds, including the dodo, 30 species of land snails, and 11 reptiles. St. Helena and Madeira in the Atlantic Ocean have lost 36 species of land snails (WCMC, 1992).

These examples raises two obvious questions. The first is whether their numbers are unusual or,

alternatively, how many species should we expect to go extinct each year? The background, that is, pre-human rates of extinctions fluctuate considerably over time and surely vary from one species group to the next. However, a convenient (and likely conservative) background rate of extinction is about "one in a million" (May et al., 1995; Pimm et al., 1995). Only about one in a million species should terminate their existence naturally within a year. The bird extinction rate is closer to one bird species per year from a sample pool of only 10,000 bird species. This means that bird extinctions are running 100 times the expected rate.

The second obvious question: Do we find evidence of massive extinctions *only* on islands?

## 2. THE DODO WENT EXTINCT (TOO BAD!)

If island species were the only ones at risk, then we consider their loss to be unfortunate, but relax in the confidence that they were especially vulnerable. This argument fails at two levels. The first failure is that high rates of extinctions occur in places other than islands. Here are three examples:

(1) A distinct and unusual flora defines the Cape Floristic Region, which occupies a small area of the southern tip of Africa. It comprises several vegetational types of which the fynbos is dominant in area and contributes the most species. Of the Region's 9030 species (Goldblatt & Manning, 2002 this issue), 36 species have become extinct in the last century, and some 618 species are *threatened* (Cowling, 1992). (I will always use "threatened" in a specific, technical sense to mean those species thought likely to become extinct within at most a few decades. Quite how long threatened species are likely to last is a topic I discuss later.)

(2) In North America's rivers, Williams et al. (1992) described the mussels and clams in the Mississippi and St. Lawrence river basins. Of the 297 North American taxa of the two families Unionidae and Margeritifidae, an estimated 21 have likely gone extinct since the end of the last century. Another 120 taxa are threatened. Miller et al. (1989) found that of ~950 taxa of freshwater fish in the United States, Canada, and Mexico, 40 have become extinct in the last 100 years. Northern lakes, southern streams, wetlands, and desert springs are very different habitats, yet all have lost species.

(3) Of the 60 species of recent mammal extinctions worldwide, 19 are from Caribbean islands (WCMC, 1992). This repeats the pattern of high extinction rates of islands, and I will not consider them further. Interestingly, 18 more were in Australia (WCMC, 1992), representing ~6% of its non-

marine mammal species. The extinctions have been equally divided between the southern arid zone—a sparsely inhabited area of mostly spinifex desert and extensive pastoralism—and the wheat belt of the southern tip of Western Australia—where 95% of the natural woodland has been cleared (Short & Smith, 1994). Another 43 Australian mammal species have been lost from more than half of their former ranges or survive on protected offshore islands (Burbidge & McKenzie, 1989).

These examples refute the criticism that extinctions are restricted to islands. In reviewing these and other examples I am struck by the diversity of taxa and ecosystems they encompass. Across these examples, indeed for all well-known taxa, recent extinction rates are 100 to 1000 times the expected rate (Pimm et al., 1995; Lawton & May, 1995).

The second failure of the "it's just islands" criticism is more surprising. Certainly, greater numbers and greater fractions of recent species extinctions have been on islands than on continents. For instance, since 1600, 97 of the total 108 bird extinctions have been on islands (Collar et al., 1994). Island biotas are uniquely vulnerable to the human introduction of previously absent herbivores, predators, diseases, and other natural enemies (Pimm, 1991). Species on continents are not so ecologically naïve.

There is another major factor that determines threat. Most threatened species have small geographic ranges (Stattersfield et al., 1998) and island species' ranges are inevitably smaller than continental ones. For a given range size, how do the island and continental fractions of threatened species compare?

Manne et al. (1999) calculated the ranges of all the passerine birds in the Americas and their associated islands. (They comprise roughly a quarter of all bird species.) To separate the effects of range size, and island versus continental distribution, we calculated the breeding range—henceforth, just "range." Some of the continental species inhabit montane habitat "islands" isolated by a "sea" of lowland habitats. We ask whether these montane species suffer different levels of threat and so separate them from lowland species.

Manne et al. showed that for the 14 lowland, 8 montane, and 27 island species with ranges smaller than 1000 km$^2$ the proportions of threatened species are high, but uncertain because of the small sample sizes. Despite these uncertainties, for these small ranges there is no evidence that island species are more vulnerable than those on continents. Perhaps one should expect this. Tiny ranges should

make species vulnerable to habitat loss, hunting, and other threats wherever the species live.

Their most surprising conclusion emerges for range sizes between 1000 km² and 100,000 km². Much *smaller* fractions of montane and island species are threatened than of lowland species. At ranges larger than 100,000 km² the proportions are uniformly small in all three groups.

This unexpected result at intermediate ranges has several possible explanations, but we consider that local abundance is the most likely (Manne & Pimm, 2001). We find that island species with a range of (say) 10,000 km² are often locally abundant on their island. Montane species with small ranges are also locally numerous within their ranges. These examples of numerous species with small ranges have no match in continental lowlands. There, species with such small ranges are almost always very rare within those ranges (Brown, 1984; Gaston et al., 1997). A reasonable explanation for the abundance of island species is competitive release (MacArthur et al., 1972). With fewer competitors, island species are able to attain higher densities and are thus less likely to be threatened.

In sum, corrected for range size, continental species are more—not less—likely to be threatened. This unexpected vulnerability of continental species offsets their putative ecological sophistication and experience of predators and other threats. There seems to be no reason why continental species will be spared the high rates of extinction humanity first vested on insular species.

## 3. Trash the Rainforests Just as Americans Did their Forests: Nothing Will Happen

Extensive reductions in the forests of eastern North America occurred during the 19th century. Surprisingly, only four bird species went extinct: passenger pigeon, Carolina parakeet, ivory-billed woodpecker, and Bachman's warbler from reasons wholly or mostly from habitat loss. Birds are well-known, so we cannot plead ignorance of their extinctions. Critics use this apparent discrepancy to claim that fears about massive global extinctions based on habitat losses are "simply wrong" (Budiansky, 1994). Just how many species *should* have gone extinct as a consequence of the loss of forests?

The answer comes from an extension of one of the most well calibrated ecological relationships (Rosenzweig, 1995). The function, $S = cA^z$, frequently provides a good description of the relationship between the size of an area, $A$, and the number of species, $S$, that it contains; $c$ and $z$ are constants.

For real islands surrounded by sea, $z$ is usually about ¼ (Rosenzweig, 1995).

Now, suppose we extend this to forest "islands" that remain amid a "sea" of deforestation. We can then predict the reduction in numbers of species from $S_{original}$ to $S_{now}$ as the habitat's area is reduced from $A_{original}$—the original extent of forest—to $A_{now}$—the area that now remains as forest "islands." The proportion of species lost ($S_{now}/S_{original}$) should be ($A_{now}/A_{original}$)$^z$. Thus $S_{now}$ equals $S_{original}(A_{now}/A_{original})^z$ and the number of extinctions, $S_{extinct}$ equals $S_{original} - S_{now}$. Notice that we need an estimate of the value of $z$, but not of $c$. Does this recipe work or are one or more of its assumptions flawed?

In North America, some 48% of the area covered by the eastern forest at the time of European settlement (1620) was still wooded at the point of its lowest forest cover (roughly 1872: Pimm & Askins, 1995). With $A_{1872}/A_{1620} = 0.48$ and $z = 0.25$, we predict that ~17% of the region's 160 forest birds (27 species) should have become extinct. It is this prediction, some six times greater than the four well-documented extinctions, that causes controversy.

Does this discrepancy cast doubt on the predictions of species losses from habitat reduction? It does not. Those who point to the small number of observed extinctions in the eastern forests mean *global extinctions*—species that are lost everywhere. The prediction of 27 extinctions is based on the number of species lost only within the region. Some of these 160 bird species would survive even if *all* the eastern forests were cleared. Their distributions across the boreal forests of Canada or into Central America would afford them a refuge while U.S. forests were cleared.

How many species *could* become globally extinct if all the eastern forests were felled? Which species are found *only* in these forests, that is, how many species are endemic to them? The answer is only 28. Now 17% of 28 ≈ 4.76. This prediction is roughly three-quarters of a species higher than the number of extinctions observed. I will not push my luck to argue that the endangered red-cockaded woodpecker, *Picoides borealis,* is three-quarters of its way to extinction. The observed and predicted numbers are remarkably close. This case history is not the counterexample critics claim it to be. North America lost few species because it had relatively few species to lose.

What happens in areas of the world that stand to lose many species? My colleagues and I have applied this recipe to two such areas. The first is insular Southeast Asia (Brooks et al., 1997, 1999a). The region comprises four archipelagos: the Phil-

ippines, the Greater Sundas (Java, Sumatra, and Borneo), northern Wallacea (Sulawesi and the Moluccas), and the Lesser Sundas. Their forests hold 585 endemic species of bird—roughly 20 times that of America's eastern forest, in half the area. About 10% of the original area is cleared per decade. Most of this deforestation has occurred recently and ~60% of the original area is still forested. Unlike the previous example, deforestation has not yet caused any confirmed bird extinctions in insular Southeast Asia. Extinctions take time following habitat loss, a point to which I must return.

What does the species-area recipe predict about the details of where extinctions will eventually occur? Across the region, some areas still have most of their forests: Borneo had ~67%, for example, when we assembled the forest cover data. (Forests are shrinking rapidly, however.) Other areas have almost none: Cebu, in the Philippines has < 1%. And some areas have more endemic species than others. Using the recipe, we predicted the numbers of threatened bird and mammal species in each of these four archipelagos, island by island. With a few, interesting exceptions, there is a statistically striking correspondence between the numbers of species we predict should go extinct and those that are currently threatened. Borneo, for example, has 38 endemics of which only 3 are considered to be threatened: the recipe predicts 4. Sulawesi and associated islands also have about two-thirds of their forest remaining, but there are 146 endemic species strewn across these islands. The recipe predicts 14 should be threatened with extinction and 16 actually are. In contrast, in the Philippines, the islands of Mindoro and the western and central Visayas have 19 endemic species; all are threatened, while the recipe only predicts that 10 should be. Where the recipe fails it usually does so by underestimating the number of threatened species: when little forest remains, other factors—including hunting and invasive species—add to the threats.

The second area is the Atlantic coast forest of Brazil (Brooks & Balmford, 1996). It has 214 endemic bird species. The area has four major subdivisions and for each there is a close match between the numbers of threatened species and those we predict should become extinct solely on the basis of habitat loss. (The lowland forests are particularly hard hit, with only 2% of the forest remaining; the recipe predicts that 7 of 11 endemic species should be threatened; 9 are threatened.)

In sum, we have a well-calibrated ecological relationship that predicts how many species should become extinct following the loss of habitat across three continents. Given enough time for the species to die, as in North America, the predictions are supported. Worldwide, for every extinct species of bird there are 10 that are threatened. We predict these much larger numbers, too, from the loss of habitat in endemic-rich parts of South America and tropical Asia. But we are still left with the criticism that the species have not yet expired. There is a lingering uncertainty that perhaps our worst fears will not be realized. That leads to the final criticism.

## 4. WHERE ARE THE BODIES?

If we are in the midst of an extinction crisis, why are more species not going extinct? The reply is that it takes time for (metaphorically) fatally wounded species to expire. The point is made by the extinctions of birds in eastern North America. The low point of forest cover for these forests was about 1870; the four fatally wounded birds lingered for several decades, perhaps even a century, before finally expiring.

This "many decades" matches many other sources of information. It fits with the IUCN definition of "threatened"—a widely held expert opinion that threatened species will likely go extinct within a few decades. And it fits exactly with the few studies that have explicitly examined forest fragments and watched how fast species disappear from them (Brooks et al., 1999b; Pimm & Brooks, 2000). These studies suggest a species survivorship curve with a half-life of roughly 50 years. That is, half the species that will eventually expire do so within the first 50 years, half of what remain expire in the next 50 years, and so on. Given these results, over what time period might the pending massive loss of species from human actions unfold?

Pimm and Raven (2000) provided several answers. The first comes from considering the large fraction of species living within tropical forests and how fast those forests are shrinking. A second answer comes from looking at the hotspots—such places as the Atlantic coast forests of Brazil and Southeast Asia where endemic species are particularly concentrated.

About two-thirds of all species occur in the tropics, most of them in tropical humid forests (Raven, 1980). Such forests include both evergreen rainforests and more seasonal ones. They originally covered from 14 to 18 million km², depending on the exact definition, and about half the original area remains (Skole & Tucker, 1993). Much of the forest reduction is recent, and clearing now eliminates about 1 million km² of tropical forest in 5–10 years. Burning and selective logging severely damages

several times the area that is cleared (Nepstead et al., 1999; Cochrane et al., 1999).

To convert habitat loss to species loss, one extends the species-area relationship derived for islands to predict how many species will not survive in habitat fragment "islands" that remain amid a "sea" of converted land—as described above. Then one updates the numbers each year as the total forested area shrinks. Species that are classified as threatened will expire in decades to come and they will be joined by other species for which we are only now destroying their habitats. The doomed species do not all die at once, but are spread over time as determined by the species survivorship curve. Combining these results gives an extinction curve that I view as no more than a first sketch that captures a few salient features.

Because the species-area curve is non-linear, the clearing to date of half the humid forests should have fatally wounded 15% of their species. This is the case. Some 12% of all plants are threatened (Walter & Gillett, 1998). This estimate is likely to be an underestimate since many rare species have yet to be described. Of course, clearing the remaining half of these forests would eliminate the other 85% of their species. Thus, the numbers of fatally wounded species should accelerate rapidly to a peak by mid century. They will be joined by ever-larger fractions of species jeopardized by the interaction between the assumed constant rate of forest clearing and the non-linear species-area curve.

The relative height of the peak depends critically on the fraction of habitat that remains. A value of 5% would protect about 50% of all the forests' species. Smaller percentages of remaining forest would lead to very much smaller estimates of surviving species. (About 5% of the world's land surface is protected at present, but that percentage includes disproportionately large areas of desert and tundra ecosystems. Protecting 5% of tropical forests will require a considerable effort.)

The time delays before extinction mean that there will be far fewer species going extinct at present than are being fatally wounded. The model predicts that current extinction rates should be modest—on the order of a hundred species per year, per million species. This matches current estimates (Pimm et al., 1995). There are as many bodies as we expect, not far fewer. Extinction numbers will also peak in mid century, but will be spread out over a century or more thereafter.

Modest tinkering with parameters does not alter the "fewer extinctions now, many more later" feature of this curve, but the contribution of Myers et al. (2000) does. They show that roughly 30 to 50% of plant, amphibian, reptile, mammal, and bird species occur in 25 hotspots that individually are no more than 2% of the ice-free land surface. These diverse taxa demonstrate that species with small ranges are numerous and they are extraordinarily concentrated. Nature has put her terrestrial species in relatively few baskets. The sample applies to the oceans: fishes and other organisms dependent on coral reefs are similarly concentrated (McAllister et al., 1994).

Myers et al. (2000) showed that human impacts are malevolent, not random. Across the 25 hotspots, an average of 12% of the original primary vegetation remains. This percentage should be compared to the roughly 50% for tropical forests as a whole. Even within the hotspots, Myers et al. found that the areas richest in endemic plant species have proportionately the least remaining vegetation and the smallest areas currently protected (Fig. 1).

A second way to sketch the unfolding extinction assumes that conservation actions immediately protect all the remaining habitat areas within the hotspots. Applying the species-area curve to the individual hotspots predicts that 18% of all their species would eventually go extinct. [Since Myers et al. (2000) showed that hotspots hold 30–50% of all species, see above, this percentage is also consistent with the fraction of currently threatened species.] Yet another sketch assumes that the hotspots' higher than global average rate of habitat loss continues for another decade until only the areas currently protected remain. The hotspots would eventually lose 44% of all their species (Pimm & Raven, 2000).

None of these three sketches captures the inadequacy of some of the protected areas, the so-called "paper parks." Nor do these ideas consider the added threat of global warming that will doubtless limit the effectiveness of sharply delimited, small reserves. Also excluded are the major threats that invasive species—introduced and weedy species—pose to the remaining species. Often listed as the most important factor in causing threat and extinction, the impacts of invasive species on islands are well known. Continents are vulnerable, too. Plant introductions are a major threat to the Cape Region of South Africa, for instance (Cowling, 1992).

The distinction between these three sketches is artificial. Many species live in tropical forests that are also hotspots. Yet others live in tropical forests that are not and some live in hotspots that are not tropical forests. Nonetheless, the sketches capture views of the size and time-scale of the processes driving the unfolding extinction.
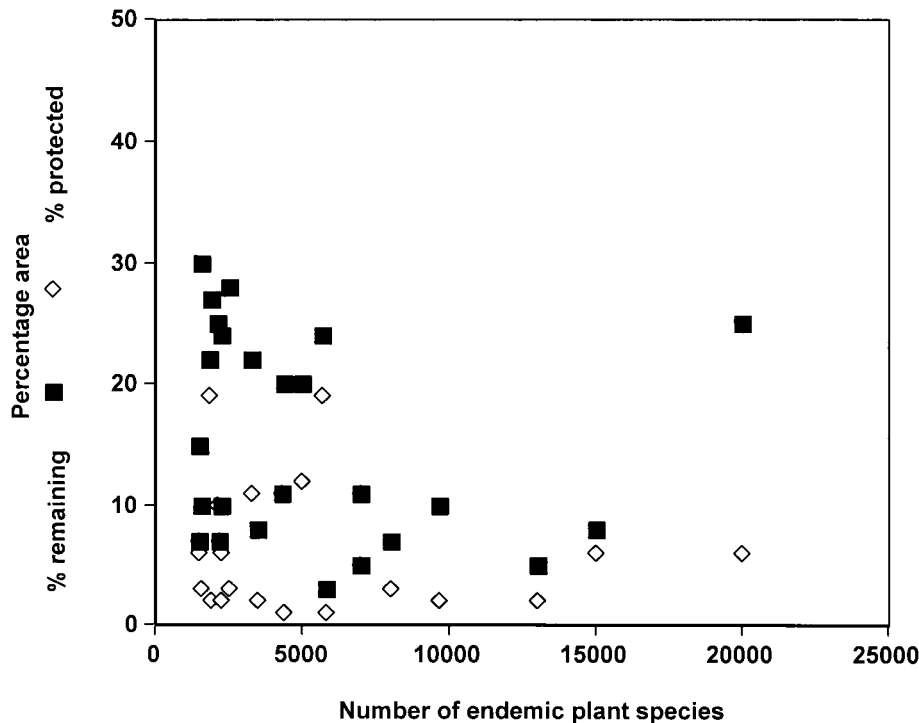
Figure 1. The percentage of the original habitat remaining and the percentage of the original habitat protected are generally smaller in those hotspots that contain the greatest number of endemic plant species. From data in Myers et al. (2000).

The first process is the rapidly accelerating loss of presently extensive, but rapidly shrinking, tropical forests. Protecting substantial and representative areas requires prompt action. This is unlikely to happen unless industrialized nations become more deeply involved with funding conservation in developing ones. Without such action, the loss of species from these areas will overtake the loss of species from hotspots within a few decades.

The second process is the rate of loss of species from hotspots. Losses here should dominate for the next few decades, since hotspots are already severely fragmented. [By definition: Myers et al. (2000) defined hotspots to have unusual numbers of endemic species and to have suffered disproportionate habitat losses.] Only immediate conservation actions, including restoration of damaged habitats, can prevent further species loss. And unless there is immediate action to salvage the remaining unprotected areas, the species losses will more than double. As Myers et al. pointed out, the current unprotected areas constitute only a little more than 1 million km². High concentrations of small-ranged species make many species vulnerable, but equally they permit a concerted effort to prevent future extinctions.

CONCLUSIONS

The dodo did not go extinct. Humanity bludgeoned it into oblivion. With it went 10% of the planet's birds and, in all probability, similar fractions of other poorly known species of plants and animals. That we did not identify and name all the species that disappeared is not a credible argument for their continued survival. The Vietnam memorial on the Mall in Washington, D.C., is a poignant list of all the Americans who died in the U.S.A.'s war in that country. A far smaller list of names appears on a memorial in the village in England where I was born to men who died in France between 1914 to 1918. I recognize those names as just a sample and, relative to the village's small population, readily extrapolate to the massive slaughter of men across the entire country. While a complete list of extinct species would be useful, it is not essential to perceive or to estimate the size of the current crisis.

Dismissing the threats of future extinctions from the few that have occurred in North America is likewise the consequence of misinterpretation. Most of the recent known bird extinctions on continents happened in North America following European

colonization. Quite what happened in Europe when its forests were cleared centuries earlier we may never know. Consequently, North America is the crucial case history of forest and species loss. It teaches that we lost 4 of 28 of its endemic forest bird species, almost exactly what the species-to-area calibrations predict on the basis of a 50% reduction of forests. (Three more species were hunted to extinction: the great auk, the Labrador duck, and the Eskimo curlew.) The major tropical forests in the Amazon, the Congo, and New Guinea have already lost half their area, are shrinking by the day, and yet they hold more than 10 times the number of bird species that were found in eastern North America. The hotspots are already depleted even further. The North American case history is most telling when scaled appropriately.

Some scientists have overestimated the numbers of species that should be going extinct per year at present. The fault lies solely with the assumption that species would die out immediately. Some do, but most manage to linger. We have yet to realize the 10% loss of species—roughly the fraction of well-known species that are threatened—because the destruction of the most species-rich ecosystems has only unfolded in the last half century. Yet this overestimation is simply fixed by changing the text from predictions of "actual extinctions" to predictions of species "being on an inexorable path to extinction." Unless we protect more of the planet's remaining natural areas, by the end of this century that distinction will seem absurdly trivial.

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