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The Sixth Extinction
by Richard Leakey and Roger Lewin (Doubleday, 1995)

Our planet has been shaken by five major extinctions in the four billion year history of life. The first, 450 million years ago, occurred shortly after the evolution of the first land-based plants and 100 million years after the Cambrian Explosion of animal life beneath the seas.

The second extinction spasm came 350 million years ago, causing the formation of coal forests. Then the Earth experienced two mass extinctions during the Triassic period, between 250 and 200 million years ago. The fifth mass extinction, probably caused by a giant meteor collision, occurred 65 million years ago, at the end of the Cretaceous period, and ended the reptilian dominance of the Earth. This led to the current mammalian domination of the Earth.

So what is the Sixth Extinction? When is it coming? And what is its cause? "It's the next annihilation of vast numbers of species. It is happening now, and we, the human race, are its cause," explains Dr. Richard Leakey, the world's most famous paleoanthropologist. Every year, between 17,000 and 100,000 species vanish from our planet, he says. "For the sake of argument, let's assume the number is 50,000 a year. Whatever way you look at it, we're destroying the Earth at a rate comparable with the impact of a giant asteroid slamming into the planet, or even a shower of vast heavenly bodies." The statistics he has assembled are staggering. Fifty per cent of the Earth's species will have vanished inside the next 100 years; mankind is using almost half the energy available to sustain life on the planet, and this figure will only grow as our population leaps from 5.7 billion to ten billion inside the next half-century. Such a dramatic and overwhelming mass extinction threatens the entire complex fabric of life on Earth, including the species responsible for it**:** Homo sapiens.

Chapter 13: The Sixth Extinction

AN ACCIDENT OF HISTORY we may be, but there is no question that Homo sapiens is the single most dominant species on Earth today. We arrived late on the evolutionary scene and at a time when the diversity of life on the planet was near its all-time high. And, as we saw in chapter 10, we arrived equipped with the capacity to devastate that diversity wherever human populations travelled. Blessed with reason and insight, we move toward the twenty-first century in a world of our own creation, an essentially artificial world in which (for some, at least) technology brings material comfort and leisure brings unprecedented artistic creation. So far, unfortunately, our reason and insight have not prevented us from collectively exploiting Earth's resources-biological and physical-in unprecedented ways.

Homo sapiens is not the first living creature to have a dramatic impact on Earth's biota, of course. The advent of photosynthetic microorganisms some three billion years ago began to transform the atmosphere from one of low oxygen content to one of relatively high levels, reaching close to modern levels within the last billion years. With the change, very different life forms were possible, including multicellular organisms, and previously abundant forms that thrived in a low oxygen environment were consigned to marginal habitats of the Earth. But that change was wrought not by a single, sentient species consciously pursuing its own material goals, but by countless, non-sentient species, collectively and unconsciously operating new metabolic pathways. The reason and insight that emerged during our evolutionary history bestowed a behavioral flexibility on our species that allows us to multiply bounteously in virtually every environment on Earth. The evolution of human intelligence therefore opened a vast potential for population expansion and growth, so that collectively the almost six billion humans alive today represent the greatest proportion of protoplasm on our planet.

We suck our sustenance from the rest of nature in a way never before seen in the world, reducing its bounty as ours grows. We are, as Edward Wilson has put it, "an environmental abnormality." Abnormalities cannot persist forever; they eventually disappear. "It is possible that intelligence in the wrong kind of species was foreordained to be a fatal combination for the biosphere," ventures Wilson. "Perhaps a law of evolution is that intelligence usually extinguishes itself"' If not a "law," then perhaps a common consequence. Our concern is: Can such a fate be avoided?

When I talk about reducing nature's bounty, I'm referring to the extinction of species that is currently occurring as a result of human activities of various kinds. In chapter 10 I described the trail of biotic destruction humans left in their wake as they swept into new environments in the prehistoric and historic past: settlers of new lands extirpated huge numbers of species, through hunting and clearing of habitats. Some modern scholars argue that this was but a passing episode in the human career and that, despite massive population expansion today, talk of continued species extinction is fallacious. It should be obvious from the tone of the preceding few paragraphs that I am not among their number. I believe that human-driven extinction is continuing today, and accelerating to alarming levels.

In the remainder of the chapter I will develop the argument for my concern. In the final chapter I will ask whether or not it matters to us and our children that as much as 50 percent of the Earth's species may disappear by the end of the next century. I will also address the longer-term future, which puts our species in a larger geological context with the rest of the world's inhabitants. And I will suggest that the insights we have gained from the current intellectual revolution I formulated in the previous chapter demand that we adopt a certain ethical position on the impact of Homo sapiens on the biodiversity of which we are a part.

Humans endanger the existence of species in three principal ways. The first is through direct exploitation, such as hunting. From butterflies, to song birds, to elephants, the human appetite for collecting or eating parts of wild creatures puts many species at risk of extinction. Second is the biological havoc that is occasionally wreaked following the introduction of alien species to new ecosystems, whether deliberately or accidentally. I talked earlier about the biological convulsion experienced by the Hawaiian archipelago through countless species of birds and plants taken there by the early Polynesians and later by European settlers. A devastation of equal magnitude is currently under way in Africa's Lake Victoria, where more than two-hundred species of fish have disappeared within the past decade. The Boston University ecologist Les Kaufman, who has studied the event in great detail, calls it "the Hiroshima of the biological apocalypse, the demonstration, the warning that more is on the way.' 12 Several interacting factors are involved, such as overfishing and pollution, but the major culprit is the voracious Nile perch, which was introduced to the lake for commercial fishing some four decades ago.

The third, and by far the most important, mode of human-driven extinction is the destruction and fragmentation of habitat, especially the inexorable cutting of tropical rainforests. The forests, which cover just 7 percent of the world's land surface, are a cauldron of evolutionary innovation and are home to half of the world's species. The continued growth of human populations in all parts of the world daily encroaches on wild habitats, whether through the expansion of agricultural land, the building of towns and cities, or the transport infrastructure that joins them. As the habitats shrink, so too does the Earth's capacity to sustain its biological heritage.

The Oxford University ecologist Norman Myers was the first to call wide attention to the impending catastrophe of deforestation, in his 1979 book, The Sinking Ark. If the rate of tree felling continued at its prevailing rate, which Myers estimated to be as much as 2 percent a year, the world would "lose one-quarter of all species by the year 2000," he wrote. A further century would add a third of the remaining species to the death toll. The decade and a half since The Sinking Ark's publication has witnessed roiling debate over the reality of the numbers. Are the forests disappearing at the rate claimed? Even if they are, would 50 percent of the world's species really disappear?

Initially, Myers's (and others') prognostications received a sympathetic hearing, and eventually built a sense of genuine alarm and concern among biologists and politicians. Grave statements flowed from weighty bodies. "The species extinction crises is a threat to civilization second only to the threat of thermonuclear war," warned the Club of Earth in a publication released at the beginning of a major conference of biodiversity, held in Washington, D.C., in September 1986. A recent joint statement by the U.S. National Academy of Sciences and the Royal Society of London must qualify as the most prestigious: "The overall pace of environmental change has unquestionably been accelerated by the recent expansion of the human population . . . The future of our planet is in the balance." Individual ecologists were equally emphatic. I'll quote two of the most prominent. Stanford University biologist Paul Ehrlich said at the Washington conference "There's no controversy among mainstream biologists that there is a crisis in biodiversity." At that same gathering, Edward Wilson stated that "virtually all students of the extinction process agree that biological diversity is in the midst of its sixth great crisis, this time precipitated entirely by man."

Just recently, however, a backlash has developed, with the doom-sayers being accused of overstating their case or, worse, fabricating it. Articles have appeared in several periodicals, expressing scepticism of the alleged danger. An article titled "Extinction: are ecologists crying wolf. "' was recently published in Science, for instance; and the 13 December 1993 issue of U.S. News and World Report ran a cover story, titled "The Doomsday Myths." These and other articles essentially suggest that although ecologists believe that many species are becoming extinct, or are about to become so, they don't actually know for sure. Julian Simon, at the University of Maryland, has been saying as much for a decade, and his voice has become even louder of late. The most prominent of the anti-alarmists, Simon wrote in a 1986 article, "The available facts . . . are not consistent with the level of concern."' In a debate with Norman Myers in New York in 1992, Simon repeated this view: "The actual data on the observed rates of speciation are wildly at variance with . . . the purported danger."' He was more direct in an opinion article he published in the 13 May 1993 issue of the New York Times: he described claims by various ecologists that current extinction rates were equivalent to those of a mass extinction as "utterly without scientific underpinning" and "pure guesswork." Professor Simon is the Dr. Pangloss of the environment.

Why has there been this criticism of scientists whose expertise supposedly is the understanding of the dynamics of biodiversity? Perhaps one reason is that the message is so startling that people are simply unwilling to hear it, or, if they hear it, are unwilling to believe it. A human-caused mass extinction is startling. Ecologists' predictions therefore came to be viewed as "the outpouring of overwrought biological Cassandras," says Thomas Lovejoy, of the Smithsonian Institution. 7 Another reason for the incredulity, no doubt, was the disparity of predictions from different authorities of the scale of the imminent extinction, which ranged from 17,000 species lost a year to more than 100,000. If the experts are so uncertain about the magnitude of the alleged extinction, critics legitimately wondered, how can we believe anything they say? I'll come back to this.

There is, I suggest, a further reason, one having to do with uncertainty of a different nature:

that is, about ourselves. If we accept that species can be pushed into extinction as easily as the ecologists are telling us, then perhaps the tenure of Homo sapiens is less secure than we would like to believe. Perhaps we, too, are destined for extinction. We dislike uncertainty about our origins; and we dislike uncertainty about our future even more.

The two pertinent questions, remember, are these: Are the tropical forests being felled at a rate near to what Norman Myers and others claim? If so, what is the impact on the species living there? The first is the easier of the two to answer directly, principally because it can be observed directly.

Myers's 1979 estimate of 2 percent of standing forest being cut each year was based on a compilation of piecemeal observations in various parts of the world, and extrapolation from these to the rest of the world. This proportion works out to be some eighty thousand square miles a year, or more than an acre a second. Dozens of studies carried out during the 1980s and early 1990s attempted to test this contention. Some claimed it to be an overestimate, some an underestimate. Now, with the use of extensive satellite imagery of much of the world's land surface, the answer is beyond reasonable doubt. For instance, two independent reports in the early 1990s, one by the World Resources Institute, Washington, and the second by the United Nations Food and Agriculture Organization, each produced figures in the range of eighty-thousand square miles of forest lost each year. (This is 40 to 50 percent higher than a decade earlier.) At this rate of destruction, tropical forests will be reduced to 10 percent of their original cover soon after the turn of the century and to a tiny remnant by 2050. Only a deliberate obscurantist would deny these numbers.

A reduction of this magnitude is bad enough for the survival of species in the forests, but there is worse news. A more recent satellite study reveals that even where forest is not clear-cut, it is often fragmented into small "islands" that are ecologically fragile. In an epic experiment begun in the late 1970s in the Brazilian forest, Thomas Lovejoy and his colleagues have been studying the ability of such islands of different sizes to sustain species. With islands varying in size from 2.5 acres to 25,000 acres, the venture is the biggest biological experiment in history. One of the expected observations is that species would become extinct more rapidly and more extensively in small patches than in larger ones. Some of the vulnerable species are those which require a large range, for various reasons. And, as we saw in earlier chapters, extinction of these species often causes other species to become extinct, too, even though they themselves don't require large territories. For instance, three species of frog vanished from one 250-acre plot early in the experiment, because the habitat was too small to support peccaries, whose wallowing in mud created ponds for the frogs. Such cascades of extinction continue for many years after the island plot is established. Other species may be vulnerable to extinction in small islands, because of the small population sizes that can be sustained there. Small populations can fall victim to sudden bouts of disease or external perturbations, such as storms, whereas large populations can weather such events.

An unexpected finding from the experiment, however, is that even large forest patches are less sturdy than might be imagined. The reason is the so-called edge effect. Habitats deep in the forest enjoy a degree of protection from external perturbation, whereas those at the boundary between forest and grassland, for instance, are exposed to winds, dramatically varying microclimates over short distances, incursion by nonforest animals and human hunters, and other inimical circumstances. The result: species of animals and plants are vulnerable to extinction for as much as a half a mile into the forest. The edge effect is therefore important even for large tracts of forest. This discovery has become especially important with the new satellite survey, which shows that logging has been leaving a vastly greater proportion of Amazonian tropical forests vulnerable to edge effects than was realized. "Implications for biological diversity are not encouraging and provide added impetus for the minimization of tropical deforestation," the investigators reported in *Science*.

The key variable in the equation, then, is the effect of forest loss and fragmentation on species survival. Before I go into this, however, it is important to emphasize that habitat loss is not confined to tropical forests. For instance, a study by the U.S. National Biological Service reported in February 1995 that during this century half the country's natural ecosystems had been degraded to the point of endangerment. Entire communities are now on the brink of extinction. In a second study, published a few months later, the service noted that "if unchecked, human activities will continue to result in an upset balance of species interactions, alterations of ecosystems and extensive habitat loss." Evidently, concern for the future of our biological heritage has to be played out in all countries of the world, not merely in the poorer, developing countries.

As I said earlier, the growth of human population worldwide is encroaching on wild habitat, both for constructing villages, towns, and cities, and the infrastructure that goes with them, and for producing food, both plants and livestock. Human population has expanded dramatically in recent history, as everyone is aware. From half a billion in 1600 to a billion in 1800; by 1940 it had reached almost 3 billion; in the past fifty years it doubled, to 5.7 billion; and it is set to double again in the next half century, to more than 10 billion. If all these people are to enjoy a standard of living above the poverty level that prevails in many of the less developed regions of the world today, the global economic activity will have to rise at least tenfold. At what cost?

Even today, humans consume 40 percent of net primary productivity (NPP) on land; that is, the total energy trapped in photosynthesis worldwide, minus that required by the plants themselves for their survival. In other words, of all the energy available to sustain all the species on Earth, Homo sapiens takes almost half. To the Stanford biologists Paul and Anne Ehrlich, the implications are ominous. "What a substantial expansion of both the population and its mobilization of resources implies for the redirection and further loss of terrestrial NPP by humanity is obvious," say the Ehrlichs. "People will try to take over all of it and lose more in the process."' For every extra I percent of global NPP commandeered by our species in the coming decades, a further I percent will become unavailable to the rest of nature. Eventually, primary productivity will fall, as space for the producers falls, and a downward spiral will eventually kick in. The world's biological diversity will plummet, including the productivity on which human survival depends. The future of human civilization therefore becomes threatened.

Not everyone accepts this doomsday outlook, of course, most particularly Julian Simon. In what must rank as one of the more daring and optimistic predictions ever made, Simon declared the following in the debate with Myers: "We now have in our hands the technology to feed, clothe, and supply energy to an ever growing population for the next 7 billion years."

One of these scenarios-the imminent threat of doom or essentially infinite human expansion-must be wrong.

The method by which ecologists calculate the fate of species in habitats that are reduced in size is based on island biogeography theory, which the Harvard biologists Robert MacArthur and Edward Wilson developed in 1963. Partly the outcome of empirical observation, partly mathematical treatment, the theory is the foundation of much of modern ecological thinking. "We had noticed that the faunas and floras of islands around the world show a consistent relation between the area of the islands and the number of species living on them," Wilson recalled recently. "The larger the area, the more the species. MacArthur and Wilson saw this relationship wherever they looked, from the British Isles to the Galipagos Islands to the archipelago of Indonesia. From these observations they deduced a simple arithmetical rule: the number of species approximately doubles with every tenfold increase in area. The qualitative relationship between area and number of species-the bigger the area, the more the species-seems intuitively obvious; and the quantitative relationship derives from empirical observation.

Though simple-even simplistic-the theory seems robust. Nevertheless, a rigorous test of the theory would make it more valuable, and this is precisely what Lovejoy set out to perform with his Brazilian rainforest experiment. Destined to continue for many more decades, the experiment has already produced sufficient information to put to rest any serious doubts about the theory's central premise.

There are many ways in which the actual number of species in a habitat of a certain size may be influenced up or down, of course. A thousand acres of flat terrain are likely to support fewer species than a thousand acres of extremely varied topography, for instance. The reason is that many more microhabitats are present in the latter than the former. And a thousand tropical acres will support more species than a similar area at high latitudes, for reasons I discussed in chapter 7. As long as appropriate comparisons are made-that is, similar latitudes, similar terrain-island biogeography theory is a powerful tool for making predictions. It is also the only tool, aside from counting species one by one; that is usually not practical. When Julian Simon says that Wilson's mathematical model "is based on nothing but speculation" and dismisses predictions as "the statistical flummery of species loss," he is being willfully ignorant of the facts underlying the theory.

Armed with this tool, what can we say about the consequences of reducing tropical forests to 10 percent of their original extent? The arithmetical relationship based on the theory predicts that 50 percent of species will go extinct-some immediately, some over a period of decades or even centuries. If most ecologists accept this empirical relationship as a reasonable guide, why are estimates of projected species extinction over the next century so much at variance with one another? Why does one authority state that 17,000 species will be lost every year while another puts the figure at 100,000?

The reasons are several, not the least of which is a great uncertainty about how many species exist in the world. As I said in chapter 7, estimates range from ten million to a hundred million. Using the same 50 percent proportion for species loss, therefore, one person using the higher estimate will produce an absolute number that is an order of magnitude greater than one who elects to use the lower estimate. There are other confounding factors, too, such as great (and unknown) differences in the size of habitat fragments that escape destruction, and uncertainties in the ranges of most species. If, for example, a significant proportion of species is restricted to small localities, then the loss of species will be higher than 50 percent, and may approach the percentage of habitat lost. "That there is considerable spread in the estimates is really not surprising, given the difficulties in getting precise information," comments Lovejoy. He then adds the key to this argument: "What is important is that every effort to estimate rates has produced a large number. Few dispute the proportion of species destined to disappear if current trends continue-that is, something close to half Fifty percent of the total of the world's species is a large number.

Even if we take a figure in the lower range of estimates, say thirty-thousand species per year, the implication is still startling. David Raup has calculated from the fossil record that during periods of normal, or background, extinction, species loss occurs at an average of one every four years. Extinction at the rate of thirty-thousand a year, therefore, is elevated 120,000 times above background. This is easily comparable with the Big Five biological crises of geological history, except that this one is not being caused by global temperature change, regression of sea level, or asteroid impact. It is being caused by one of Earth's inhabitants. Homo sapiens is poised to become the greatest catastrophic agent since a giant asteroid collided with the Earth sixty-five million years ago, wiping out half the world's species in a geological instant.

The figures I've been talking about are predictions for extinction rates early in the next century if current trends of habitat destruction continue. Critics not only doubt the validity of these predictions, but also challenge ecologists to produce hard evidence of an alarming level of human-caused extinctions today. It is true that, because there has been no comprehensive, global survey, ecologists are unable to proffer such evidence in the form of a complete list of extinctions. In effect, however, the critics are implying that no such evidence exists because no (or very few) species are disappearing as a result of human activity. Despite the lack of a comprehensive survey, there is a large body of isolated studies in many different habitats around the world. Dismissed by the critics as "merely anecdotal," these studies collectively give more than enough reason for concern.

I will offer some examples. I've already mentioned the massive loss of fish species in Lake Victoria. By itself, the disappearance of two-hundred species in twenty years is already way beyond the background extinction rate of one species every four years. If background extinction rates applied to birds, for instance, ecologists should expect to see the disappearance of a bird species no more frequently than once every century. And yet, as Stuart Pimm reports, "In the Pacific alone, we are seeing about one extinction per year." Pimm's field work is in Hawaii, where birds are his special interest. The Hawaiian islands may look like a tropical paradise to tourists, but to ecologists they bear the scars of recent, catastrophic extinctions. As many as half the islands' bird species have gone extinct since first human contact, and the loss continues today. Of some 135 bird species there, only eleven thrive in numbers that ensure their survival well into the next century. "A dozen . . .,are so rare that there is little hope of saving them," says Pimm. "A further dozen are legally classified as Endangered-meaning that their future survival is uncertain."

A little more than a decade ago, ninety species of plants became extinct in a virtual instant, when the forested ridge on which they grew was cleared for agricultural land. The ridge, in the western Andean foothills of Ecuador, is called Centinela, and among ecologists the name has become synonymous with catastrophic extinction at human hand. By chance, two ecologists, Alwyn Gentry and Caraway Dodson, visited the ridge in 1978 and carried out the first botanical survey in its cloud forest. Among the riot of biodiversity that is nurtured by this habitat, Gentry and Dodson discovered, were ninety previously unknown species, including herbaceous plants, orchids, and epiphytes, that lived nowhere else. Centinela was an ecological island, which, being isolated, had developed a unique flora. Within eight years the ridge had been transformed into farmland, and its endemic species were no more.

Centinela had a unique flora, but it wasn't unique in being an ecological island. Countless such ridges exist along the whole length of the Andes, most of which, too, must have developed species not found elsewhere. What made the Centinela habitat notorious was that a botanical survey had been carried out prior to its destruction. Each time an ecological island is cleared, species will vanish in a virtual instant, an event ecologists now term a Centinelan extinction. There are two points to be emphasized here. The first is that whenever ecologists are able to survey a habitat before and after disturbance, species loss is almost always seen, often a catastrophic one. However, in the vast majority of instances, habitat destruction occurs in areas that have not been surveyed for their flora and fauna, so it is more than likely that countless species become extinct before ecologists even know of their existence. How is one to document this, except by extrapolation? The second is that, like the plants on Centinela, many species have very limited ranges, particularly in the tropics, so destruction of habitat often results in the instant destruction of species. As I indicated earlier, this implies that the 50 percent figure predicted for eventual species loss is more likely to be an underestimate than an overestimate.

The list of "anecdotal" evidence is long: half the freshwater fish of peninsular Malaysia, ten bird species of Cebu in the Philippines, half the forty-one tree snails in Oahu, forty-four of the sixty-eight shallow-water mussels of the Tennessee River shoals, and so on. The evidence may be anecdotal in the sense of its not being the result of a systematic survey, but it is compelling nonetheless. In an attempt to be quantitative with the known extinction data, and thereby come up with an assessment of whether or not we face a biological crisis of our own making, Stuart Pimm and two of his colleagues analyzed some of the best known and most closely documented cases. These include freshwater mussels and freshwater fish in North America, mammals in Australia, plants in South Africa, and amphibians worldwide. "What causes extinction?" Pimm and the others ask rhetorically. "Our reading of the five case studies is that species introductions and physical habitat alteration are the highest-ranking factors." I won't go into the details of the recorded extinctions, because they can be found in Pimm's publication; instead, I'll concentrate on the conclusions that flow from the analysis of them.

If the observed levels of extinction known in these cases is typical for similar species worldwide, then current extinction is running at a rate some thousand to ten-thousand higher than background extinction. Skeptics may argue that these examples represent particularly high levels of extinction, and are therefore not representative. Even if this is the case, say Pimm and his colleagues, and these known extinctions are the only ones in these groups of species worldwide, which is highly improbable, then the rate is still two-hundred to a thousand higher than background. This qualifies as a mass extinction. The authors point out that none of the cases is from areas where human densities are particularly high, illustrating that the hand of death is effective at a distance. How much more effective would it be, then, in the midst of high concentrations of humanity? Pimm asks what we are to conclude from this and other studies: "Those who suggest that high extinction rates are a fabrication seem curiously ignorant of the facts or, perhaps, willfully ignorant.

The documentation of known extinctions may seem to be the only way to demonstrate that we are in the midst of a biotic crisis, and this is what skeptics demand. After all, there can be no case for murder without a body. Equally, if a population of a species exists somewhere, it is not extinct, is it, even if its total range is reduced by habitat destruction? However, this point of view underestimates both the magnitude of the current crisis and its complexity. "It is important to recognize that, except when all individuals of a species are simultaneously eliminated, as by a meteor or hurricane, extinction is a multi-stage process," observes Daniel Simberloff. By way of example, he cites the case of the heath hen, which I recounted in chapter 5. The cause of extinction is usually given as hunting and habitat destruction by humans. The bird's range, remember, was huge, and covered much of the eastern seaboard of the United States. Hunting and habitat destruction reduced the species' number to fifty individuals in 1908, when a reserve was established to save it from extinction. Over the next two decades the population's numbers began to rise robustly, but eventually the species did go extinct, through a combination of biblical calamities, including fire and pestilence.

The point of the story is that once the heath hen population was reduced to small numbers, its eventual extinction was virtually assured. As I've stated several times, a small population is vulnerable to normal fluctuations in its numbers, the consequence of disease and disasters. A population of a thousand individuals can weather a population drop of a hundred; such a fluctuation spells the end for a population that starts with only a hundred individuals. In the case of the heath hen, even when hunting and habitat alteration were halted, its survival was precarious in the extreme. A proper assessment of the impact of human activity on current biodiversity therefore must take into account populations that have become so small, victims to stochastic fluctuations or are trending in that direction. This is precisely what Stuart Pimm did in describing the prospects of the Hawaiian birds. Only eleven are assured of survival well into the next century. Populations of the remaining 124 species have already been reduced, in some cases perilously so. Yet a simple species accounting notes that 135 species exist: no extinction to report. Simberloff describes the predicament graphically: "Many populations, including the last populations of some species, might be superficially healthy but among the living dead."

I believe that the "anecdotal" accounts of extinctions worldwide that ecologists are currently telling us about are but the merest hint of a catastrophic reality that is unfolding silently and, for the most part, away from our sight. Given the absolute impossibility of documenting the demise of every species whose fate is sealed by human activity, we need to be acutely sensitive to these faint echoes on the wind, because they carry an important message. Dominant as no other species has been in the history of life on Earth, Homo sapiens is in the throes of causing a major biological crisis, a mass extinction, the sixth such event to have occurred in the past half billion years. And we, Homo sapiens, may also be among the living dead.

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