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The Terminator (*Homo exterminans*)

The Lord Krishna said:

Doom am I, full-ripe, dealing death to the worlds, intent on devouring mankind

—*Bhagavad Gita, translation by Mahatma Gandhi.*

When Lonesome George passed, alone and in the dead of night, the world Pinta Island tortoise population slipped quietly into oblivion. George was a member of a subspecies, *Chelonoidis nigra abingdonii*, that had for two or three million years inhabited a single island in the Galapagos. Discovered by Hungarian biologist József Vágvölgyi in 1971, George lived out his last years in captivity and solitude, the only one of his tribe left alive. Desperate efforts by conservationists from the Charles Darwin Foundation to mate him with female tortoises of different subspecies from neighbouring Isabella and Española islands came to nothing. Eggs were laid, but no baby tortoises ever hatched. On June 24, 2012, George was found dead by his carer of 40 years, Eduardo Llerena. It appears he died of heart failure aged around 100 years—not great for one of these large, long-lived creatures, which are known to attain 175 or more (Galapagos Conservancy 2014).

Perhaps it was simply a broken heart. The humans immediately began to fight over who should have custody of his carcass. A Yale University team asserted that the Pinta tortoises still existed in certain genes discovered in another subspecies on another island (Ingber 2012), but if your immediate family is dead and your distant cousins in another land are alive, it doesn't

seem quite the same, somehow. In the final washup, George was simply the latest victim of *Homo sapiens*, whose whalers and fishers used for two centuries to stock up on fresh tortoises to eke out their shipboard rations when they called at the Galapagos and whose feral goats—introduced for similar reasons—stripped Pinta Island bare of all the vegetation the tortoises needed to subsist. Nothing we did subsequently could save him.

Around the world, the mournful tale of Lonesome George is echoing, time and again, with dismaying frequency. On the same day he passed, as many as a 100 other animals and plants blinked into nothingness, unhymned by the world media, blithely unnoticed by the vast majority of *Homo sapiens*, the species that has now come to dominate all others and to occupy the lion's share of the planet's resources.

Like death, extinction—let it be said—is a part of life. Nearly all the plants, animals and organisms that ever lived on Earth are now extinct (Raup 1986). Without extinction, you don't get evolution, adaptation or major change. New species, such as ourselves, cannot emerge to replace old ones, try out new physical and mental adaptations, explore new niches: without it we'd still all be dwellers in the primordial ooze. Extinction has been going on constantly ever since life began here, 3.8 billion years ago. It isn't extinction that is the big worry: it's the *rate* of extinction. To illustrate with a simple analogy, if you smash your car into a tree at a speed of 5 km an hour, you'll probably walk away with scarcely a bruise. Try it at 160 kmh and the effect is catastrophic, for driver and passengers alike. In extinction as well as motoring, speed counts.

Establishing how many species there are on Earth is a task fraught with difficulty: early estimates ranged wildly, from three million to upward of 100 million. However, as techniques improved a team led by Camilo Mora and Boris Worm of Dalhousie University in Canada, modelled species relationships to predict there are probably about 8,700,000 different species currently living on Earth—but possibly as few as 7.4m or as many as 10m (Mora et al. 2011). These include 7.77 million species of animals, 298,000 plants, 611,000 species of fungi, 36,400 species of single-celled animals and 27,500 species of algae. But here comes the crunch: "In spite of 250 years of taxonomic classification and over 1.2 million species already catalogued in a central database, our results suggest that some 86% of existing species on Earth and 91% of species in the ocean still await description," they said. Thus, we're losing living things we don't even know are there. We are losing, forever, a large part of our planet without ever having explored it.

A second vexed question is how fast do species vanish—and is the current rate normal or not? To answer this Juuriaan de Vos of Brown University and colleagues analysed the family trees of living organisms to arrive at an estimate

that under Earth's 'normal' conditions—i.e. without human interference or asteroids smashing into it—around one species (out of the roughly 9m species now living) goes naturally extinct every year (De Vos et al. 2014). However, investigations by Gerardo Ceballos, Paul R. Ehrlich and colleagues found “an exceptionally rapid loss of biodiversity over the last few centuries, indicating that a sixth mass extinction is already under way.” They concluded that the average rate of vertebrate species loss over the past century has been 100 times higher than the background rate. “The evidence is incontrovertible that recent extinction rates are unprecedented in human history and highly unusual in Earth's history. Our analysis emphasizes that our global society has started to destroy species of other organisms at an accelerating rate, initiating a mass extinction episode unparalleled for 65 million years. If the currently elevated extinction pace is allowed to continue, humans will soon (in as little as three human lifetimes) be deprived of many biodiversity benefits. On human time scales, this loss would be effectively permanent.” Averting a dramatic decay of biodiversity and the subsequent loss of ecosystem services was still possible through intensified conservation efforts, the scientists felt—but that window of opportunity was rapidly closing (Ceballos et al. 2016).

The International Union for the Conservation of Nature (IUCN) is the world's oldest and largest global environmental organisation, with more than 11,000 volunteer scientists worldwide supplying it with information on the state of life on Earth (IUCN 2016). Though it works on many aspects of conservation, the IUCN is best known for its celebrated 'Red List' of threatened species, the world's most comprehensive database on the status of imperilled animal, fungi and plant species and their connection to human livelihoods—a list it has maintained and developed for over half a century (The IUCN Redlist of Threatened Species 2016). As of 2016, the Red List had scientifically assessed 83,000 species, finding around 24,000—almost one in three—to be at risk of extinction. It has a publicly accessible internet search engine which enables anyone who is interested, with a little persistence, to discover the current status of any listed life form.

Here is a bird's eye view of what's happening to the world's wildlife, summarised by the California-based Centre for Biological Diversity:

- FROGS: about 2100 of the world's 6300 known frogs, toads and salamanders are in danger, with an extinction rate 25–45,000 times above 'normal'.
- BIRDS: 12 % of the world's 10,000 known bird species are classified as endangered, and 200 of these are on the brink of extinction.
- FISH: Worldwide 1851 species of fish—21 % of all fish species evaluated—were deemed at risk of extinction by the IUCN in 2010.

- **INSECTS:** Of the 1.3 million known insect and invertebrate species, the IUCN has evaluated about 10,000 species: about 30 % of these are deemed at risk of extinction.
- **MAMMALS:** Half the globe's 5491 known mammals are declining in population and a fifth are clearly at risk of disappearing forever. 1131 mammals across the globe are classified as endangered, threatened, or vulnerable.
- **PLANTS:** Of the world's 300,000 known species of plants, the IUCN has evaluated 13,000 and found more than two thirds of these are threatened with extinction.
- **REPTILES:** Globally, 21 % (or 600) of the total evaluated reptiles in the world are deemed endangered or vulnerable to extinction (Centre for Biodiversity 2016).

In 2014 the scientific journal *Nature* estimated that 765 species had vanished since the year 1500, and 5522 were on the brink (Monastersky 2014). On average, it found, between 10 and 700 species were disappearing each week, due to habitat loss and degradation (44 %), overexploitation (37 %), climate change (7 %), invasive species (5 %), pollution (4 %) and disease (2 %). Figure 2.1 shows the most threatened mammal species, by country.

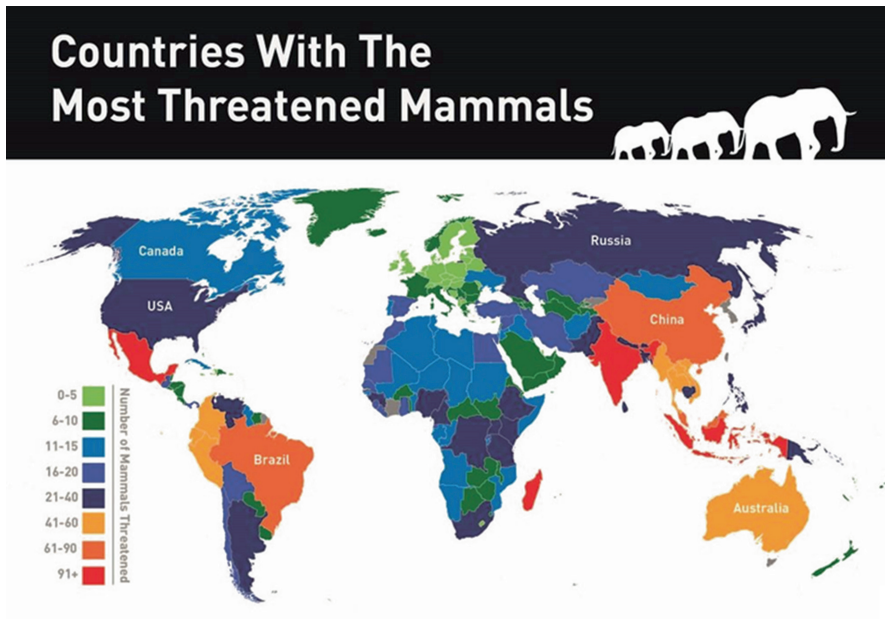


Fig. 2.1 Countries with the most threatened mammals. *Source:* www.theecoexperts.co.uk, data from the World Bank

Mass die-offs of wildlife also appear to be on the rise, according to a study by US researchers. These are staggering events in which more than 90 % of a particular population—often over a billion individuals—perishes. They analysed 727 such events recorded worldwide since 1940, affecting 2407 animal populations, found that their magnitude has increased and was intensifying for birds, fish and marine invertebrates, decreasing for reptiles and amphibians and staying the same for mammals. Most appeared to be caused by starvation, disease, poisoning and multiple stresses (Fey et al. 2014).

Even more alarmingly, a report from the Worldwide Fund for Nature (WWF) found that more than half (52 %) of the world's wild animals vanished in the 40 years post 1970. Land animal numbers were down 39 %, freshwater animals by 76 % and sea creatures by 39 %. The decline in animal, fish and bird numbers was calculated by analysing 10,000 different animal populations representing 3430 different species. WWF said the declines were variously due to over-exploitation by humans (37 %), habitat decline and loss (44 %), climate change (7 %) and other factors (11 %) (see Fig. 2.2) (WWF 2014).

As for animals, so too for the world's plants. A study for the International Union for the Conservation of Nature (IUCN) concluded in 2015 that “More than 20% of plant species assessed are threatened with extinction... the habitat with the most threatened species is overwhelmingly tropical rain forest, where the greatest threat to plants is anthropogenic habitat conversion,

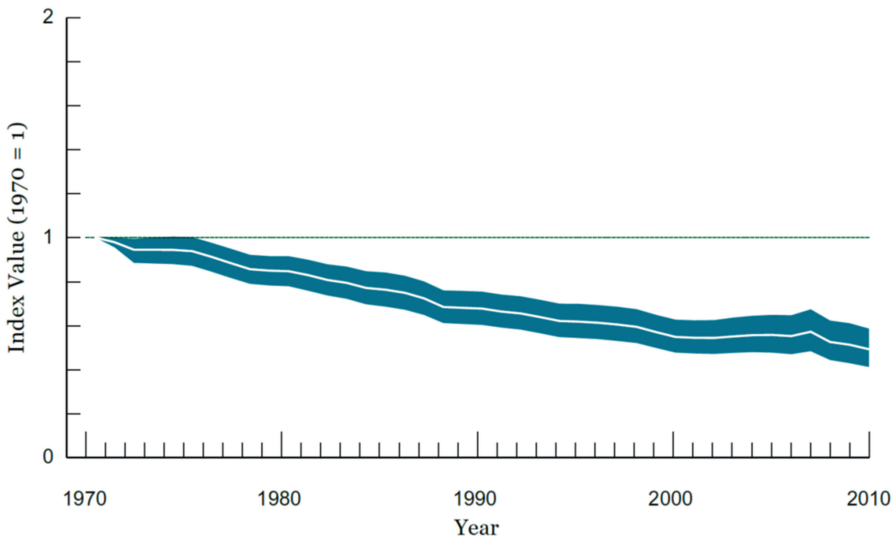


Fig. 2.2 Decline in world wild animal numbers. Source: WWF (2014)

for arable and livestock agriculture, and harvesting of natural resources.... Urgent action is needed if we are to avoid losing one in five plant species,” it concluded (Brummitt et al. 2015).

Harvard scientist EO Wilson, regarded by many as the world’s greatest living biologist, says:

We are tearing down the biosphere. Without abatement, the current rate of human activity will result in as many as half the species of plants and animals being extinct or on the brink of extinction by the end of the century. I don’t think the world can sustain this. It really will be forever (Glancy 2014).

The Frogs: A Modern Tragedy

When Aristophanes wrote his comic play *The Frogs* around the fifth century BC, the little creatures were abundant, their chorus a tuneful backdrop to daily life almost everywhere. By the early twenty-first century frogs and other amphibians, for more than 300 million years among the hardest and most resilient of lifeforms ever to colonise the Planet, have become the most imperilled group of animals on Earth, their song increasingly stilled. Two in every five of their known species face extinction and there has been a collapse in numbers in all countries and environments, even in the remote wilderness.

Frogs are the perfect illustration of the complex, multi-tynd character of the human assault on the natural world. Their decline and demise is due to no one factor, but to the interaction of many: habitat destruction, infectious diseases, pollution and use of pesticides, climate change, invasive species, and over-harvesting for the pet and food trades.

One of the biggest frog-killers, the chytrid fungus, illustrates the point. This infection has been found in 287 species of frogs and toads, in 37 countries on six continents in a pandemic that is now considered impossible to eradicate (Kriger and Hero 2009). While superficially the infection appears natural, in fact scientists now consider, it was we who spread the chytrid fungus worldwide. Its earliest origins have been traced to South Africa in 1938 and a native frog, *Xenopus laevis*—the African clawed frog—which carries but is immune to it. Around the same time, in 1934, medical scientists made a marvellous discovery that was to change world history for people and for frogs alike: if you inject a frog with a woman’s urine, the hormones reveal whether or not she is pregnant. “Soon after discovery of the pregnancy assay for humans in 1934, enormous quantities of the [clawed frog] species were caught in the wild in southern Africa and exported around the world” (Weldon et al. 2004). Following this, the clawed frog became one of the world’s lab animals of choice, because it

was so easy to keep and breed. Inevitably, some escaped from captivity and established new populations in the wild, alongside native frogs who were susceptible to the fungus and whom they infected, with deadly consequences.

Frog populations anywhere close to modern agriculture, transport or cities were already reeling from a multiple toxic assault from pesticides, air and water pollution, plastic particles, oil and chemical spills, endocrine disrupting chemicals, lead, mercury and other heavy metals. This undermined their health, and their immunity to new diseases. The same poison flood also kills many insects on which frogs rely for their food. Development has led to the draining of marshes, wetlands and shallow aquifers, the emptying of creeks, the clearing and drying-out of once well-watered landscapes to raise grain and cities. And the irresistible decline in frog numbers in turn has spilled into declines in birds, fish, reptiles and small animals that feed on them.

The tragedy of the frogs is a story not only of importance to the fate of life on Earth in general: it is linked to the human destiny also. For we, too, are an involuntary target for many of the same assaults to which we have subjected frogs—and the evidence is mounting that they are starting to exact a heavy existential toll on us too. Frogs, in short, are the canary in the planet's coal mine, their fading calls the early warning of a gross ecological breakdown which will strike humanity harder than anything in our experience. To this we can either choose to succumb—or together take urgent steps to avoid it.

The Hand of *Homo*

That humans are implicated in the dramatic acceleration in loss of species now being seen around the world is no longer doubted by the tens of thousands of researchers who study the issue. “In the past 500 years, humans have triggered a wave of extinction, threat, and local population declines that may be comparable in both rate and magnitude with the five previous mass extinctions of Earth's history,” state Rodolfo Dirzo and colleagues in an article in the journal *Science* (Dirzo et al. 2014).

“We live amid a global wave of anthropogenically driven biodiversity loss: species and population extirpations and, critically, declines in local species abundance. Particularly, human impacts on animal biodiversity are an under-recognized form of global environmental change,” they add. “Of a conservatively estimated 5 million to 9 million animal species on the planet, we are likely losing 11,000 to 58,000 species annually”.

It is not simply the loss of species like the Pinta tortoise or Africa's northern white rhino which concerns biologists: more alarming still, in their view, is the collapse in abundance of creatures and plants which only a few decades or even years ago, were plentiful. In the case of insects, for example, Dirzo's team found two thirds of the species studies show an average decline of 45 % in abundance. Using information from the IUCN's Red List they found that 60 % of beetle species studied had suffered serious loss in numbers, as had 45 % of ants, 25 % of butterflies—and every single species of grasshoppers and crickets they looked at.

While many people will be little moved by the loss of 'creepy crawlies', such a massive extirpation of insects spills over to affect the numbers of birds, frogs, reptiles and fish that rely on insects as food, and the decline of these in turn affects larger animals. It impairs the successful pollination of plants which provide up to a third of the world's food supply, as well as the renewal of landscapes and forests. Modern plants have evolved largely to depend on insects to fertilise them: lose insects and the whole web of life attenuates and, in some cases, collapses. Like a string of tumbling dominoes, the fall of ecosystems in turn reaches all the way to humans, undermining our own wellbeing through the loss of the services which natural systems provide—clean water, air, food, waste recycling, pollination of crops and seed dispersal of plants, building and furnishing materials, medical drugs, health and recreation.

As the young Australian conservationist Bindi Irwin, daughter of the world-renowned TV naturalist Steve Irwin, graphically explains: "If you keep on pulling one brick after another out of your house, eventually the house falls down" (Surviving Earth 2014). That, say the scientists, is what is now happening, at a planetary scale. This event is so profound it has earned its own name in the geological history of the Earth: the 'Anthropocene defaunation' or, more colloquially, The Sixth Extinction (see for example, Leakey 1996; Kolbert 2014).

Silent Oceans

A major extinction event driven by humans is poised to occur in the world's oceans, similar to the one which has already taken place among land animals over recent history. That's the finding of a study by American marine biologists, who say:

Humans have profoundly decreased the abundance of both large (e.g., whales) and small (e.g., anchovies) marine fauna. Such declines can generate waves of ecological change that travel both up and down marine food webs and can alter

ocean ecosystem functioning. Human harvesters have also been a major force of evolutionary change in the oceans and have reshaped the genetic structure of marine animal populations. Climate change threatens to accelerate marine defaunation over the next century (McCaulay et al. 2015).

Today's rates of marine extinction "may be the prelude to a major extinction pulse, similar to that observed on land during the industrial revolution, as the footprint of human ocean use widens," they warn, adding that "habitat destruction is likely to become an increasingly dominant threat to ocean wildlife over the next 150 years". However, they consider there is time for humanity to act meaningfully to prevent a wipe-out in the oceans comparable to that taking place on land.

The grim outlook was borne out in 2015 by the Worldwide Fund for Nature (WWF) whose *Living Blue Planet Report*, found "The LPI [Living Planet Index] for marine populations, compiled for this report, shows a decline of 49 per cent between 1970 and 2012. This is based on trends in 5829 populations of 1234 mammal, bird, reptile and fish species" (Worldwide Fund for Nature (WWF) 2015). Looking specifically at tuna and mackerel, the study noted a 74 % collapse in numbers and "no sign of overall recovery at a global level". That humans could eliminate almost half of all large sea life across the world's oceans—which span 71 % of the surface of the planet—in just 42 years, offers a frightening insight into our destructive capability as a species.

A specific example of how far afield the human hand now reaches is the loss of an estimated 70 % of the world's seabird population—equivalent to 230 million birds—since 1950, as revealed in a study by the University of British Columbia. By far the greatest declines were observed in far-ranging ocean-going species like albatrosses (Paleczny et al. 2015). "Seabirds are particularly good indicators of the health of the oceans," lead author Michelle Paleczny commented. "When we see this magnitude of seabird decline, we can see there is something wrong with marine ecosystems. It gives us an idea of the overall impact we're having." A study by Australia's CSIRO and Imperial College London found that 90 % of seabirds had fragments of plastic in their gut in 2015 and by 2050 this would apply to 99 % of the world's remaining seabird population (Wilcox et al. 2015).

The plight of the oceans is nowhere better illustrated than in the case of Australia's Great Barrier Reef (GBR), the largest living organism on the planet, covering a third of a million square kilometres. In 30 years, half the Reef has died (Australian Institute of Marine Science 2012). In 2016, an estimated 93 % of the remaining reef was hit by the worst episode of coral bleaching ever recorded. Some scientists warn that the GBR and most of the world's

corals may be gone by 2050 (Koronowski 2016)—the result of a combined assault from human activities including global warming, ocean acidification, nutrient, sediment, oil, chemical and pesticide runoff, dredging, overfishing, boat damage, and plagues of coral diseases, weeds and pests like the Crown of Thorns starfish linked to these human-induced stressors.

If humans can kill off a living organism as large as the Great Barrier Reef through neglect, mismanagement and ignorance, they can kill off anything on Earth, including themselves.

Mass Extinction

The fossil record reveals at least five mass wipe-outs since complex multi-cellular life first appeared in the primeval seas some 700 million years ago, and about a hundred lesser ones. A mass extinction is one in which around three quarters of all the species alive at the time die out. The ‘Big Five’ are:

- Ordovician-Silurian: a double event about 450–440 million years ago killed off 27 % of all families alive at the time, 57 % of all genera and 60–70 % of known species.
- Devonian: about 350 million years ago, a prolonged event lasting up to 20 million years, eliminated about 19 % of all families, 50 % of all genera and 70 % of all species.
- Permian: 250 million years ago the worst event in the known story of life on Earth took out 96 % of all marine species, including all the trilobites. Corals reefs vanished for at least 15 million years. 70 % of land species were also lost, for a grand total of 90 % of all life on Earth at the time.
- Triassic-Jurassic: about 200 million years ago another vast upheaval eliminated 70–75 % of land and water species.
- Sixty-six million years ago the KT or Cretaceous-Palaeogene event, now widely attributed to an asteroid striking the Earth, wiped out three quarters of all known species, including most of the dinosaurs—with the exception of a handful of smaller ones which evolved into today’s birds.

The chain of events leading to these five extinctions, especially the older ones, is still debated. The earliest, for example, has been speculatively linked to an exploding star—a supernova—which went off with a bang at the time, and may have been close enough to deluge the Earth with deadly gamma radiation. Or it may have had another cause entirely, which is lost in time. There are at least 15 major theories of natural mass extinction which include:

vast outbreaks of volcanic activity which poison the air and waters; sudden episodes of global warming or global cooling which throw nature and food chains into chaos; rapid sea-level falls bringing death to shallow-water animals; meteorite or comet impacts throwing up vast clouds of dust and causing a freezing ‘nuclear winter’ in which plants die and food chains collapse; the explosive release of frozen methane deposits in the seabed, disrupting the climate, poisoning the seas and collapsing food chains; loss of oxygen in the oceans and shallow waters caused by the release of nutrients and huge bacterial blooms; ‘ocean overturn’ where changes in the salt balance and temperature cause the oceans to physically flip upside down, asphyxiating sea life and causing climate havoc. In the worst extinction episodes, it is probable that several of these factors operated in concert with one another to produce the comprehensive tragedies that are graven into the fossil record. It is also likely that extreme climatic change featured in all of them.

The Permian event, for example is variously considered to have started with an outbreak of volcanic flood basalts in Siberia, a massive comet impact or an explosion of methane from the seabed. These in turn released vast volumes of toxic gases and dust into both the atmosphere and waters of the planet. The release of massive amounts of carbon dioxide cooked off by volcanic heat from existing coalbeds and the burning of forests—and recorded in rock strata from that time—may have precipitated a sudden spike in the planet’s temperature causing climate chaos and acidifying the oceans, with a resulting collapse in marine food chains. The sudden die-off by a large part of the Earth’s life and the erosion of denuded landscapes then poured nutrients into the oceans and fresh waters prompting vast blooms of fungi and bacteria which feasted on the rotting detritus and stripped the waters of their life-giving oxygen, killing off fish and other survivors. For a while, fungi ruled the Earth. Though it is hard to decipher, the fossil record suggests that mass extinctions seldom occur all at once, but instead proceed in a series of distinct pulses, probably due to the sort of cascade of lesser catastrophes described, each one wiping out a new class of animals and plants that had managed to outlive the preceding onslaught. That, researchers fear, is exactly what we are witnessing today—but the causes, and the consequences, lie much closer to home (Ward 2007) .

The Age of Homo

Today, we humans and all living things, inhabit a new age—The Anthropocene. Originally coined to describe our own geological era, the name was adapted by Nobel laureate and atmospheric chemist Paul Crutzen to mean the age

in which humans have emerged as a force of nature, with an almost tectonic influence on the planet and all that it contains.

“Human activities are exerting increasing impacts on the environment on all scales, in many ways outcompeting natural processes,” he wrote. “This includes the manufacturing of hazardous chemical compounds which are not produced by nature, such as for instance the chlorofluorocarbon gases which are responsible for the “ozone hole”. Because human activities have also grown to become significant geological forces, for instance through land use changes, deforestation and fossil fuel burning, it is justified to assign the term “anthropocene” to the current geological epoch. This epoch may be defined to have started about two centuries ago, coinciding with James Watt’s design of the steam engine in 1784” (Crutzen 2006).

Others agree about the start date, but link it to the agricultural revolution which in turn launched the human population boom, widespread deforestation of the planet and the universal loss of soils.

The chief fingerprint of the Anthropocene is the gas, carbon dioxide. Released by the burning of coal and oil and the clearing of land, at the beginning of the modern age its level in the Earth’s atmosphere was about 270 parts per million (ppm). By 1950, with industrialisation, this had climbed to 310 ppm (Steffen et al. 2007). Today it stands at over 400 ppm and is on track to reach 600 ppm by mid-century. According to the Australian National University’s Will Steffen and Paul Crutzen “Since (1950) the human enterprise has experienced a remarkable explosion, the Great Acceleration, with significant consequences for Earth System functioning. Atmospheric CO₂ concentration has risen from 310 to 380 ppm since 1950, with about half of the total rise since the preindustrial era occurring in just the last 30 years. The Great Acceleration is reaching criticality. Whatever unfolds, the next few decades will surely be a tipping point in the evolution of the Anthropocene.”

When scientists talk about a ‘tipping point’ they mean a moment when a system suddenly flips from one, relatively stable, state into another. A river once clear, clean and full of life, turns foul, turbid and lifeless due to pollution and sediment. An area of sea once abundant with fishes, crustaceans and shellfish turns dead and sterile due to a massive influx of fertiliser, chemicals and soil. A forest or grassland becomes a desert, from land-clearing, fire or overgrazing. A lake or forest dies from acid rain. A coral reef is overgrown with weed, and is abandoned by its brightly-hued and diverse fishes. A rainforest is cut down, its soils become so acidic that trees can no longer grow and the land is covered in poor-quality grasses. In all these cases it is extremely difficult,

if not impossible, to restore the environment to the state that prevailed before disaster struck, at least on human time frames. Too many important species have been lost. Too much has changed, chemically, hydrologically and in terms of the microbial populations that support life. A ‘tipping point’ is a euphemism: in practicality, it means a point of no return.

Most reasonable people would be appalled if they knew the full extent of the damage they do to their planet and all life on it, simply by the innocent acts of feeding their family and making a home. It is the nature of the modern world that we are separated and insulated from the actual destruction by long industrial and commercial chains that blind us to the realities of mass consumption. For example, environmentalists argue that the extraction of groundwater water by lithium miners has been a major factor in the collapse of flamingo populations on the salt lakes of the Atacama—yet such is the length of the market chain that few owners of a mobile phone, tablet, laptop computer, drill, electric car or other battery-powered device feel personally responsible for the destruction of wild birds, in a desert far, far away (Fischer 2015). And yet they are. Caring citizens of modern society often express deep concern over the extermination of iconic African and Asian elephants and rhinos by poachers, or the impending loss of polar bears from Arctic ice melt—but also seldom feel responsible for the vanishing of fertile soils, the stripping of forests and vegetation and the microbial life that supports them, benign insects, and hundreds of small birds, frogs, or native rodents. Yet, through the global economy we are, all of us, now engaged in this self-harming act of pulling down our own house. Every dollar we spend on food and consumer goods sends out a tiny monetary signal that drives the relentless diminution, destruction and poisoning of forests, savannahs, soils, rivers, oceans, species and clean air. We are the ones whose insatiable appetite for minerals, meat, grain, timber, chemicals and fossil energy is transfiguring our world beyond recognition—and for all time.

The ‘Superpredator’

Humans have been implicated in the loss of species for thousands of years. In his celebrated book *The Future Eaters*, palaeontologist Tim Flannery argued that humans were a factor in the extinction of the ice-age megafauna—the giant mammoths, woolly rhinos, cave bears, elks, sloths, giant birds and diprotodons—in the continents of Europe, America, Asia and especially, Australasia (Flannery 2002). Rapid climate change from the frozen world of the last ice-age to the warm world of the Holocene may have pushed these animals to the

brink, but there is now little doubt that humans helped shove many of them over it, usually by hunting but more recently by land clearing for agriculture and cities. In Australia, Flannery argues, it was not so much hunting as fire-stick farming by Aboriginal Australians across the continent that modified the grazing environment so profoundly that the giant kangaroos and diprotodons could no longer survive in it, a continental-scale event that echoes the micro-tragedy of Lonesome George and the Pinta Island tortoises. Today such continental catastrophes are being repeated in Africa and Asia, last homes of the world's megafauna—the elephants, giraffes, lions, tigers, antelope, buffalo, apes and rhinos—which are going down to overwhelming human need, greed and pressures, just as the wolves, lions, bison, bears, wild horses, lynx and aurochs of Europe did in previous centuries.

The bloody thumbprints of humans are to be found all over the crime scene in the disappearance of several hundred large animals during the past 10,000 years¹. In the last 500 years there is little forensic doubt about who took out the dodo. Or the New Zealand moa. Or the Steller's Sea Cow. Or the North American passenger pigeon. Or the quagga, the sea mink, the Labrador duck, the Great Auk, the Hokkaido wolf, the Tasmanian 'tiger', the Atlas bear, the Texas wolf, the Japanese river otter, the Caspian tiger, the eastern cougar, the western Black rhinoceros, the Formosan clouded leopard. But less well-understood are the means. In a worldwide study of predation, scientists at Victoria University, British Columbia, concluded:

Our global survey ... revealed that humans kill adult prey, the reproductive capital of populations, at much higher median rates than other predators (up to 14 times higher), with particularly intense exploitation of terrestrial carnivores and fishes. Given this competitive dominance ... humans function as an unsustainable "super predator," which—unless additionally constrained by managers—will continue to alter ecological and evolutionary processes globally (Darimont et al. 2015) .

Despite our predatory primacy, not every wild animal to become extinct is hunted to its doom. Many, such as small birds, marsupials and plants, have been hardly hunted or harvested at all. Today the main drivers of extinction are more subtle and begin with the overwhelming pressure of the growing human population, our insatiable hunger for resources and the flood of poisons we release when we access them (Chap. 6). Though it is hard for us to conceive, we humans are now so numerous and demanding, that we occupy around 25 % of the Earth's net primary productivity, the organic carbon that is the basis of all life on the planet (Haberl et al. 2007). In other words we commandeer a quarter

¹ (For a partial list see http://en.wikipedia.org/wiki/Timeline_of_extinctions).

of all the available energy for life on Earth, rendering that quarter unavailable for other species. But as our population climbs by another third to 10 or 11 billion, as it likely to do this century if current trends persist and, more importantly, if many of those billions attain the affluent lifestyles of America, Europe or Australasia which involves tripling their demand for resources, then by the late century humans alone will dominate well over half of the planet's total carrying capacity. Species that can adapt to us—dogs, cats, cattle, rats, pigeons, roses, corn, cockroaches, ebola, flu, TB, HIV and zika—may prosper and claim their share of the spoils. Others will fade away. Furthermore, besides absorbing the planet's primary energy flows, humans also perturb the Earth system in other ways, through pollution, chaotic change in food webs, landscapes, water supplies, climate and ecosystem services, on all of which other species depend for their survival. A disturbing study by Tim Newbold and colleagues found that, across almost two thirds of the Earth's land surface, species richness has fallen below 10%, considered one of the safe limits for human survival (Newbold 2016). The rise in human populations and extinctions is compared in Fig. 2.3, from the US Geological Survey (Scott 2008).

Of all the human impacts which affect other creatures and plants, by far the largest is our practice of modifying natural landscapes and seascapes, so they support less and less wildlife. The main reason we modify these environments

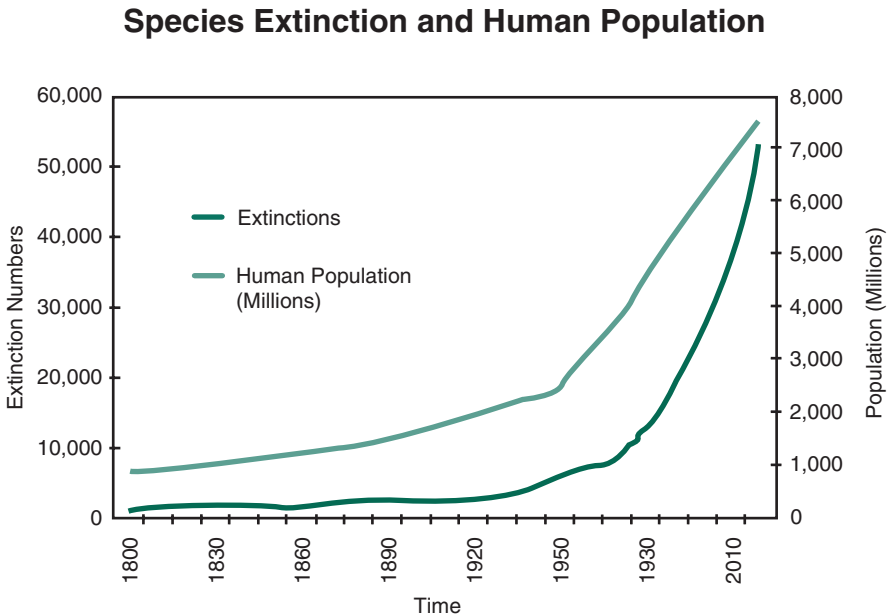


Fig. 2.3 Species extinction and human population. Source: US Geological Survey, 2008

is for farming, fishing and grazing in order to supply the food we need each day: from an extinction point of view the human jawbone is by far the most destructive implement on Earth today, and becoming deadlier with each passing day as an additional 200,000 of us sit down to dinner, and call for richer foods (Chap. 7).

Wild species are lost when forests fall, savannahs and rangelands are stripped bare, seas trawled empty, lakes, rivers and aquifers are drained and deserts spread. This is well documented. But there are second-round effects that are equally damaging—torrents of lost topsoil that render waters stagnant or uninhabitable; floods, droughts and wildfires that result from the way we are modifying the landscape and climate; a global outpouring of toxic chemicals into air, water, soil and the food chain, some of which poison animals outright, others of which subtly damage their health or impair their ability to reproduce; the creeping acidification of oceans and lakes. While no single factor may drive a species into extinction, their formidable combination is proving increasingly lethal to more and more life. Together, they render our world less and less habitable for wildlife. And ultimately, for humans too.

Could We Become Extinct?

Over the 3.8 billion-year history of life on Earth, around 99.9% of all species ever to emerge have gone extinct. Despite this ominous statistic, however, many people nowadays cherish a notion that, somehow, this essential biological truth doesn't apply to us. That we're different. Some imagine our recent technological prowess exempts us from this immutable rule of life, others that a benign deity will intervene to save us. In a good many cases extinction is simply too distasteful or depressing a topic for people to contemplate, and they prefer to stick their head in the sand and pretend it won't happen. This, alas, is not a tactic for survival.

According to the fossil record, the typical Earth species survives for about ten million years before succumbing to its fate or evolving into something else—though there are whole families of long-distance champions like sharks (who have hung round in one form or another for 420 million years), jellyfish (550my) and algae (2+bny). In evolutionary terms this means the modern human race is barely out of the starting blocks compared with these venerable competitors, although our ancestral primate line reaches back 55 million years (Perkins 2013). Our direct lineage extends for only about 4–5 million years, our actual species *Homo sapiens* about 200,000 years and our modern subspecies, *H.s.sapiens* a mere 40,000 years. Until recently the greatest risks of humans becoming extinct came from the natural world but now, as Britain's

Astronomer Royal, Martin Rees points out: “This is the first century in the world’s history when the biggest threat is from humanity” (Coughlan 2013).

Lurking somewhere in our gloomy ancestral closet may be a number of hideous crimes against our own kind. The human lineage, back to the time when we shared a common ancestor with chimpanzees, contains at least a dozen different species of human-like creatures, one or more of which are almost certainly our direct ancestors. How many of these distinct ‘hominin’ species existed rather depends on which palaeontologist you speak to—the issue is debated with ritual calumny in academic circles. On the one hand, the Georgian scientist Dr David Lordkipanidze argues on the basis of a handful of skulls that we are all from a common, but physically highly variable, lineage directly descended from early *Homo erectus* around 1.75 million years ago (Lordkipanidze et al. 2013), while his critics dispute this (Schwartz 2000), arguing instead for anywhere from nine to seventeen distinct species in the family tree of humans—*Australopithecus africanus*, *A. robustus*, *Homo ergaster*, *Homo habilis*, *H. erectus*, *H. pekinensis*, *H. heidelbergensis*, *H. soloensis*, *H. floresiensis* and *Homo sapiens neanderthalis*, to name some of the most prominent (Curnoe 2013). Exactly what became of each of these early human ‘cousins’—whether they evolved into us, died out, interbred with or were wiped out by one another along the way—is not known. The most celebrated family mystery is the fate of the Neanderthals: whether or not they died out as a result of genocidal pressure from Cro-magnons—as argued by Jared Diamond (Diamond 1993)—suffered from a change in climate for which they were ill-adapted, were out-competed and starved as a result of colliding with a more advanced hunting culture, or simply interbred with the Cro-magnons and became us. Improved carbon dating indicates they vanished quite suddenly, in less than 2000 years, about 40,000 years ago (Higham et al. 2014), while the discovery of a 50,000-year-old toe bone from the Altai mountains in Siberia has yielded enough Neanderthal DNA for scientists to pronounce with confidence there is a fair bit of it still walking around today, in us, and that a certain amount of interbreeding must have taken place (Prüfer et al. 2014). However, the stark and unambiguous message of our own lineage is that *no kind of human is exempt from extinction*, no matter how smart it may deem itself. This is a piece of wisdom we need to ponder as we contemplate and plan our longer-term survival.

History, from the conquests of the New World and India, the rape of Africa, the Mongol invasions, the massacres of the American Plains Indians, Australian Aborigines and Russian Kulaks to the Holocaust and failed Nazi attempt to clear ‘Lebensraum’ for German settlers in Eastern Europe, makes it abundantly clear that we humans are intensely competitive when it comes to grabbing the resources for living that we covet. Unlike other predatory

animals, we have little compunction about systematically exterminating whole races and cultures who stand in our way—a practice still going on today as contemporary urban/agricultural society continues to overwhelm, engulf, digest and eliminate the hunter-gatherer cultures (i.e. those with the greatest knowledge of how to live in balance with nature) of most continents. An unpalatable piece of self-knowledge if we are to survive the next 100 years is that ‘genocidal’ is inscribed on the human CV from our early days, and is not merely a phenomenon of recent centuries or the province of particular races, creeds and nations. There is a dark tendency to our nature which we must vanquish if we are to avoid being the authors of our own undoing in the twenty-first century.

Possible human extinction through our own actions is now regarded as sufficiently credible a risk to command serious academic attention. In 2004 Britain’s Astronomer Royal, Professor Martin Rees, published *Our Final Century* in which he argued humanity has only a 50:50 chance of seeing out this century, based on the dangers of technology run amok (Rees 2004). Professor Nick Bostrom of Oxford University’s Future of Humanity Institute (FHI) says:

Our species is introducing entirely new kinds of existential risk — threats we have no track record of surviving. Our longevity as a species therefore offers no strong prior grounds for confident optimism. Consideration of specific existential-risk scenarios bears out the suspicion that the great bulk of existential risk in the foreseeable future consists of anthropogenic existential risks — that is, those arising from human activity. In particular, most of the biggest existential risks seem to be linked to potential future technological breakthroughs that may radically expand our ability to manipulate the external world or our own biology.

On the upside, Bostrom adds that “Public awareness of the global impacts of human activities appears to be increasing... Problems such as climate change, cross-border terrorism, and international financial crises direct attention to global interdependency and threats to the global system. The idea of risk in general seems to have risen in prominence. Given these advances in knowledge, methods, and attitudes, the conditions for securing for existential risks the scrutiny they deserve are unprecedentedly propitious. Opportunities for action may also proliferate” (Bostrom 2013).

Current scenarios for human extinction (or partial wipe-out) being explored by the Oxford Future of Humanity Institute and others include:

- Severe climate change (+3–6 °C), collapsing world food supplies and ecosystems leading to mass migration, resource wars (Dyer 2009) and disease pandemics (McMichael 2012) (This book, Chaps. 4, 5, 7 and 9).

- Uncontrollable or ‘runaway’ climate change (+8–30 °C), causing the Earth to overheat to temperatures where it becomes physically uninhabitable by humans or any other large animals (Hansen et al. 2013) (Chap. 5).
- Nuclear wars, arising out of religious, resources, ethnic or political disputes, followed by a ‘nuclear winter’ of collapsing social order, widespread famine and disease (Chap. 4).
- Developments in information technology reaching a point where human intelligence is exceeded and then supplanted by machine intelligence, a theory popularised by physicist Stephen Hawking (Cellan-Jones 2014) (Chap. 8).
- Chain consequences flowing from research into synthetic biology, nanotechnology or quantum physics, such as the unintentional creation of destructive self-replicating organisms, machines or substances, or the breaching of unknown physical boundaries (Chap. 8).
- A global pandemic caused by a newly-evolved or man-made infectious virus, such as a strain of influenza which attacks the brain and spine. These already exist in birds and could cross into humans (Chap. 8).
- Ecosystem collapse; or a more subtle and protracted process in which the progressive decline of climatic, biological and environmental services and scarcity of key resources interacts with loss of intelligence and health as a result of pandemic self-poisoning with man-made chemicals and new diseases (Chaps. 2, 3, 6 and 8).
- A process in which delusion becomes so paramount in politics, business, economics, religious beliefs, popular narratives and the behaviour of society that it paralyses our ability to take effective pragmatic action to save ourselves (Chap. 9).
- More optimistically, that our species successfully evolves from our present form into a wiser type of human with the pan-species ability to communicate, co-operate, nurture, conserve and share wisdom universally—rather than one that prefers competition, exploitation, killing and destruction (Chap. 10).
- An unavoidable Earth system catastrophe such as an asteroid impact or large scale outbreak of volcanism such as may have caused the Permian and/or KT extinctions, or a gamma ray burst from a nearby exploding star.

It will be apparent on reading this short list that most forms of human extinction are avoidable, except, possibly, for the last. However, everything depends upon the degree of wisdom we can bring to bear collectively in anticipating and preventing them from reaching a critical pitch. That humanity has already entered the extinction danger zone is attested in research by

some of the world's leading thinkers on this issue—Johan Rockstrom, Will Steffen, Brian Walker, Hans Joachim Schellnhuber and Terry Hughes among others—who identify seven planetary boundaries which humanity ought not to cross for its own safety (and three of which we have already transgressed) (Rockström et al. 2009). We will return to this idea in the concluding chapter.

The take-home message from *this* chapter is this: *extinction is optional*. At least in the current century. It's a choice, for you and me. And our properly understanding the most likely causes is the start of a species-wide process for avoiding them.

Equally, ignoring the possibility of human extinction is a good way to guarantee it. Human survival in the C21st depends less on the malign intentions of the few, than on a majority of good people doing little or nothing to ensure it.

The avoidance of human extinction will demand co-operation across a very much-enlarged species of 10 or 11 billion individuals, on a hitherto undreamed-of scale. It will require the collective wisdom—not just the individual intelligence—to foresee, understand and counteract the self-imposed dangers that confront us. It will necessitate fundamental changes in human nature, belief systems, power-sharing, equality and behaviours—including, especially, a shift from competitive to collaborative thinking (Chap. 10). The main risks and their possible remedies will be explored in coming chapters.

Furthermore, the global decision to avoid extinction has to happen *fast*. As Ian Chambers puts it “It is impossible to overemphasise the urgency with which the human race needs to respond to and manage these global challenges. Time is not on our side. What we do or do not do in the next decade will shape the long-term future of our planet and all who live upon it” (Chambers and Humble 2012).

Finally, it should be observed that, under most of the scenarios described above, complete human extirpation is still unlikely in the current century. A more imminent risk is the collapse of civilisation in the chaos arising out of the uncontrolled burgeoning of several dangers and their interaction with one another, rather than any single cause. This is the complexity crisis, which humans will undoubtedly face in the twenty-first century.

A Plague of Teddy Bears

In recent decades the number of toy stuffed animals in the world has multiplied faster, far faster, than humans. Poor households now harbour several of these cute effigies of the natural world, while rich homes boast dozens and occasionally hundreds. Of the 70 or so new toys that the average American

child is presented with each year (Tuttle 2012), a tenth or more are toy animals. Some malls and shopping centres have retail outlets whose sole trade is in stuffed toys. Museums and even conservation bodies flog millions of replica wild animals, soon to vanish from the Earth. If a Martian statistician were to conduct a global census, they would probably find that stuffed toys now outnumber humans and other animals several fold, and might even conclude they are the true masters of the Earth...

It may seem whimsical to use something as apparently innocuous as teddy bears as an indicator for man-made eco-collapse and extinction, but they are emblematic of how detached humans have become both from the natural world and from the realities of survival in it. There is something unhinged, disconnected and rather pathetic about a creature which devotes so much time, energy and money to rubbing out real, live animals—and replacing them with lifeless surrogates, mostly made from the very petrochemicals that contribute to extinction. On the one hand our love of stuffed toys betokens our sentimental attachment to aspects of the disappearing natural world. On the other it bespeaks our brute indifference to the fate of actual wild animals with whom we share this world: we can love something fake, artificial, childish and anthropomorphic, but care little for the real thing. While first and foremost a failure of empathy and ‘humanity’, our love affair with stuffed toys also symbolises a profound failure of wisdom, the inability to grasp that we run the risk of ‘stuffing’ ourselves, along with the rest of Nature in our thrall.

Preventing Extinction

It is entirely feasible for humanity to slow and maybe even to halt the rising tide of extinctions—but not by the half-measures now in place around the world. Zoos, national parks, marine reserves, cryogenic ‘arks’, conservation and breeding programs, tree-planting schemes and private collectors may salvage a few fragments of the jigsaw of life which we inherited—but not the big picture. These are the product of wise individuals, who understand the scale of the losses, and are doing their very best to staunch them within the limits of insufficient resources and funding and a largely uncaring, unwise society. Only a wise human *species* can halt the current losses (see below and Chap. 7).

For every person working to conserve an animal, a plant, a landscape or marine area, a million are spending their money in ways that, often unbeknown to them, guarantee that the destruction will continue and even increase.

What would a wise humanity do? Here are some possible approaches, drawn from a growing scientific consensus, with potential to make an Earth-wide difference. Significantly, all of them contain a ‘win-win’ for humans as well as for the natural world and improve our prospects of surviving the twenty-first century with our civilisation intact. Probably the most important and far reaching, articulated by biologist E.O. Wilson, is to set aside half the Earth for the rest of life: “The only way to save upward of 90 per cent of the rest of life is to vastly increase the area of refuges, from their current 15 per cent of the land and 3 per cent of the sea to half of the land and half of the sea. That amount, as I and others have shown, can be put together from large and small fragments around the world to remain relatively natural, without removing people living there or changing property rights” (Wilson 2016a).

What We Must Do

1. Replace half the world’s farmed and grazed area with sustainable, climate-proof intensive food systems, mainly in cities and in coastal waters. This will enable the progressive ‘re-wilding’ of an area of 25 million square kilometres (equal in size to the continent of North America) and its return to its natural vegetation and wildlife.

Pathway: see Chap. 7 for more detail but broadly this entails the rapid shift of half or more of the world’s food production capacity into cities to protect it from climate shocks and water shortages and to recycle nutrients. This demands radical change in urban planning (to recycle water and nutrient waste), to encourage food production, accelerate investment and increase R&D into greenhouse, hydroponic, aquaponic and bioculture systems.

2. Sustainable grazing (eg ‘precision pastoralism’) of the world’s rangelands will enable livestock numbers to be reduced, carbon to be locked up, vegetation and water cycling to be restored and pastoral incomes improved. This will lead to many wild species being far better conserved across the savannahs, which cover 40 % of the Earth’s land area (see Chap. 7)

Pathway: the concept of ‘precision pastoralism’—using satellites and automated mustering to balance feed availability with livestock numbers—allows far more sustainable grazing of rangelands and better incomes for pastoralists. It will be up to governments to drive this by ensuring the availability of technology and training.

3. Replace destructive fishing methods with sustainable forms of aquaculture on land and at sea, based on farmed algae.

Pathway: aquaculture is already taking off as ocean fish catches dwindle and the cost of farmed fish production falls with technological advances. It will be greatly accelerated by the farming of algae as a major new feed supply for both farmed fish and other livestock as well as for human food and renewable transport fuel.

4. Replace coal, oil and gas with renewable energy. This will eliminate the world's main source of toxic pollution, which is currently harming wildlife as well as all humanity directly and indirectly, through brain poisoning and reproductive dysfunction, immune breakdown and climate change.

Pathway: See Chap. 4. Detailed pathways and options for climate change mitigation has been laid out by the IPCC (IPCC 2014a) and in many individual government reports². They include strategies such as accelerated investment in renewables, carbon cap-and-trade systems, distributed energy generation, energy efficiencies in industry, transport and cities, smart energy technologies, reafforestation and revegetation of landscapes and recycling of materials, most of which hold additional benefits for the natural world in terms of reduced toxicity and increased wilderness.

5. Build a global biosecurity network to combat the introduction and impact of invasive species.

Pathway: under development. Requires far stronger quarantine and species import/export rules as well as control of marine pests, and exotic insect and fungal introductions. Increased priority among government agencies of biosecurity risks.

6. Develop a plan to progressively restore the world's great forests, manage the oceans (especially outside sovereign borders) and cleanse the world's seas, rivers and fresh waters of toxins, plastics and eroded soil.

Pathway: progress in this regard has been slow in some areas and has stalled in others. It can be reignited by a global 'Clean Up the World' strategy (Chap. 6), and reinvestment in programs such as the UN's REDD reforestation scheme.

7. Build into all food and consumer goods a small charge to fund the repair or prevention of the ecological damage caused by their production. This should be regarded as a wise re-investment in natural capital, not an 'eco-tax'.

Pathway: the simplest way to do this is through a consumption tax on food that is earmarked specifically for reinvestment in natural capital and repair of damaged landscapes and waters. To avoid regressivity, the poor can be exempted, supplied with food stamps or other concessions.

² (See, for example, Germany: <http://www.eea.europa.eu/soer/countries/de/climate-change-mitigation-national-responses-germany>).

8. Use the funds so raised to pay the world's 1.8 billion farmers and indigenous people to act as on-the-ground stewards of global biodiversity and fund conservation programs for vital habitats and keystone species.

Pathway: see Chap. 7

With an issue such as extinction the individual, even if wise enough to understand and lament it, often feels helpless to prevent it. The good news is that this need no longer be the case. Here are some measures we can all take in our own lives to ensure the survival of as many other lifeforms as possible.

What You Can Do

- Be an informed consumer. Learn which foods and goods degrade and destroy the natural world and which heal it—and exercise your economic power and freedom to send a clear signal to industry, your nation and the world economy. Freedom isn't just a right—it's a responsibility.
- Use the internet and social media to learn the scientific facts of extinction and share them with friends, family and followers. Play your part as an educator and leader in the online global conservation movement. Stand up for endangered and 'keystone' species.
- Educate your children about the value of wildlife and natural landscapes, how they support us—and what we lose when we degrade or destroy them.
- Support politicians and companies with a track record for devoting real resources to protection of wildlife and landscapes.
- Avoid products that use plastics, pesticides, endocrine disruptors, VOCs and other contaminants that kill or incapacitate wildlife.
- Choose foods and consumer goods that reduce human pressure on the natural environment and encourage 're-wilding'.
- Work through local volunteer, social, religious and sports groups to repair your local environment, restore its species and spread the word about sustainable consumption.
- Don't buy any more stuffed toys. Spend the same amount on a good conservation body or activity (like tree planting) and save a real animal to delight your grandkids. Get them involved in wildlife sponsorship schemes.

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