Is life on Earth really at risk? The truth about the extinction crisis

Earth's biodiversity isn't just beautiful, it ensures human survival. But to protect nature's bounty we first need to know exactly how we're harming it

La Scarlatte

By **Graham Lawton**

"SEE those little beetles with a black cross on a red background?" I lean in to take a look. "They're Panagaeus cruxmajor – the crucifix ground beetle. They were collected by Charles Darwin back in the 1820s."

Ed Turner is curator of insects at the University of Cambridge's Zoology Museum, where many of Darwin's beetle collections are held. He is proud to show me specimens collected by the man himself, and I am chuffed to see them. But the thrill doesn't last. If we were to follow in Darwin's footsteps and go out hunting crucifix ground beetles on the fens north of Cambridge, Turner says, we would have no chance. "They're extinct. In this county, anyway."

You would have to be living under a rock not to have heard about the biodiversity crisis. Since about 1500, expanding human activity has condemned vast numbers of mammals, birds, amphibians and reptiles to an early grave. Now worries have spread to smaller creatures that actually do live under rocks, in leaf litter, in dung heaps and in puddles and ponds.

Turner is in no doubt. "Insects are in massive decline and have been for some time," he says. "It's quite a clear picture and a depressing one. By any measure that you choose, biodiversity of insects is declining." I ask him what that means. "It means something is very, desperately wrong with our world."

So is this it? Are we really on the brink?

Biodiversity is important. Life doesn't just adorn the world with beautiful things, it also provides ecosystem services – pollination, seed dispersal, water filtration, nutrient recycling, soil generation and so on – without which we couldn't function either.

However, working out what's going on with biodiversity soon meets a fundamental problem: there is an awful lot of it, and counting it is hard work. You need legions of biologists in the field sampling, sampling, sampling, going back to the same places again and again to capture long-term trends. But this isn't glamorous or sexy science, and the legions aren't there.

It doesn't help that biodiversity is something of a nebulous concept. The term first appeared in the 1980s, and came into popular usage after the Convention on Biological Diversity was unveiled at the Rio Earth Summit in 1992. But its meaning is surprisingly hard to pin down.

Learn more about biodiversity at New Scientist Live: See ecologist and evolutionary biologist Chris Thomas explain how the fates of humans and nature are inter-twined

"In some settings, biodiversity has come to mean 'everything'," says Mark Vellend, a conservation biologist at the University of Sherbrooke in Canada. "You could just insert the word 'nature'. That's not a useful scientific term at all."

The simplest measure of global biodiversity is "species richness", which just means the number of species alive right now. This is not known; current estimates range from 2 to 10 million, not including bacteria and archaea. So richness is usually measured in terms of its evil twin, the extinction rate. "The global extinction rate is I think the most fundamental measure of biodiversity loss," says ecologist Georgina Mace of University College London. "How many species are there on the planet and how much is that decreasing over time?"

Dire warnings on that score are nothing new. In 1979, UK environmentalist Norman Myers predicted in his influential book, The Sinking Ark, that a million species would be driven to extinction by the year 2000.

Going, going, gone

To the best of our knowledge, that hasn't happened. Many extinctions have been documented,

extinctions. That's less than 1 per cent of all 91,000 species on the list and a negligible fraction of the estimated number on Earth. A further 757 are listed as "possibly extinct". But 44,148 are of "least concern", red-list jargon for not under threat of extinction.

Olar Barndõk/NHM Images

Species have been going extinct for billions of years without human intervention. To assess our contribution, we need to know the background or natural rate of extinction. From the fossil record this is typically calculated to be about 1 extinction per million species per year.

On that measure, to have snuffed out nearly 1 in 100 of the species on the IUCN list looks very bad. "Extinction rates are about 1000 times above the background rate; there is no discussion about that," says José Montoya, a biologist at the CNRS Theoretical and Experimental Ecology Station in Moulis, France.

Then again, most of what we know about the decline of biodiversity from the IUCN list concerns a limited group of large and fairly obvious animals such as mammals, birds and amphibians. All of these are in trouble. A quarter of the 5488 mammal species on the list are threatened. For amphibians, it is 41 per cent; birds, 13 per cent.

But extinction rates are a blunt measure of the biodiversity crisis. "Species progress towards extinction," says Mace. "They lose abundance, but rarely actually go extinct." A more detailed picture is provided by the Red List Index, which tracks how rapidly mammals, birds, amphibians and corals are progressing through the categories, from vulnerable through endangered, critically endangered, extinct in the wild and extinct. By this measure, biodiversity is clearly in decline.

about whether enough of the right species are there to provide those crucial ecosystem services.

Insects such as leaf-cutter ants keep ecosystems ticking over
Bence Maté/NHM images

The best measure of this, says Mace, is the Living Planet Index, devised and maintained by conservation group WWF and the Zoological Society of London. This crunches data on 19,500 populations of more than 4000 vertebrate species from around the world. It, too, contains a stark warning. The latest version of the index, published in 2016, shows that since 1970, the abundance of vertebrates has declined by 58 per cent. Over the past 50 years we have lost more than half of the big animals on Earth.

That seems bad. But big, rare animals are possibly quite unrepresentative of life as a whole. To really understand what is happening to biodiversity you need to know about the small and unglamorous things that do most of the work keeping the ecosystem ticking over: insects, and also fungi, algae, crustaceans, molluscs and so on.

In June, UK TV presenter and naturalist Chris Packham captured the antsy zeitgeist surrounding these creatures when he tweeted: "I've been in my garden in Hampshire for the last couple of days. Sunny, plenty of wildflowers. Not a single butterfly. Not one. Nothing. And in the woods a handful of Speckled Woods. I think we are at a point of absolute crisis in our countryside."

Everyone I talk to has an anecdote of this kind. For Turner, it is the decline in butterflies on his father's lawn. For Montoya, the almost total disappearance of red coral from his study sites in the Mediterranean Sea.

your car smeared with pureed flies. Nowadays, he says, insect strikes are a rarity. In 2004, an informal study carried out by the UK Royal Society for the Protection of Birds using cardboard "splatometers" attached to the front of cars recorded an average of just one splat every 8 kilometres. I check my own car: I recently drove the 200 kilometres or so out from London to the leafy Weald of Kent and back, but find only two small squished corpses on my registration plate.

50%
average reduction in animal population size between 1970 and 2012

Source: WWF/ZSL Living planet index

But these are anecdotes, not data. "The jury is really out over whether invertebrates are following similar trajectories to vertebrates," says Mace. "I don't think we really know at the moment."

Perhaps that is why a research paper published last year caused such a stir. It was the result of surveys carried out in 63 nature reserves in western Germany, starting in 1989. Every year, in early spring, the team pitched tent-like insect traps in one of a number of carefully selected locations to catch low-flying insects. They were left up throughout the spring, summer and early autumn, emptied every few days, and their haul of insects weighed.

This is exactly the sort of meticulous, long-running biodiversity experiment that we desperately need if we are to understand what is going on. And the findings were horrific. In the early 1990s a single trap would typically catch around 8 grams of insects a day. By the mid-2010s, that had slumped to just 2 grams. The number of flying insects in spring and summer had dropped by an average of 75 per cent.

The finding was quickly dubbed "insect Armageddon". To Turner, it came as no big surprise: it fitted with what we already knew. UK butterfly abundance has declined three-quarters in the past 30 years. Europe's grassland butterflies declined by 50 per cent between 1990 and 2011; wild bees and moths have fallen by similar amounts. The German study was simply the first to confirm an overall, dramatic decline in all flying insects.

Nonetheless, there are reasons to think things are not that cut-and-dried. Most of the collection sites in the German study were only sampled once in 27 years. It is possible, though unlikely, that the results indicate variation in space rather than time. And it only measured the total mass of insects caught in the traps. "To me that is decidedly not a measure of biodiversity," says Vellend. "The total mass of something doesn't fit the word 'diversity'."

The story of insect Armageddon also doesn't entirely chime with some other, even longer-running, insect-trapping experiments. In 1964, researchers at the Rothamsted Experimental Station, now Rothamsted Research, in Hertfordshire, UK, began operating a nationwide network of 78 light and 16 suction traps that has been collecting insects from the same

change in insect biomass at three of them.

In the UK, there have been declines in butterflies, moths, dragonflies and carabids, the family to which the crucifix ground beetle belongs. But other groups seem to be doing fine. "Pest insects haven't gone down," says Leather. "Aphids don't seem to be showing any downward trend, despite us spending a lot of money trying to control them." He also points to a 42-year study of insect populations in cereal fields in south-east England, which showed that some had gone down, some had gone up and some had stayed the same.

The basic problem, says Leather, is a lack of data. "We have some long-term studies, but we don't have enough." And that is for insects in the UK, one of the most intensively entomologised countries in the world. Elsewhere the records are "very patchy", says Turner, especially in the tropics. "It's an incredibly undiscovered world." As for other invertebrates, forget it.

58.1 %
of the world's land surface has severely compromised biodiversity

Source: Biodiversity Intactness Index

In 2015, a group of conservation biologists based in France revealed the depth of our ignorance in a paper called "Mass extinction in poorly-known taxa". They pointed out that, even though all 15,528 known bird and mammal species are on the IUCN Red List, only 1 per cent of 1.4 million invertebrate species are. Of these, more than a quarter are classed as "data deficient". Those that have been evaluated tend to belong to larger and more charismatic groups: butterflies, dragonflies, corals and certain snails. "Invertebrates are still essentially unevaluated," they concluded.

These glaring gaps in our knowledge mean that any claim of a global biodiversity crisis among insects and other invertebrates, however plausible, must remain an untested hypothesis.

That isn't to say that we can't make educated guesses. One group of invertebrates for which we have quite good data is molluscs. According to the IUCN, this group has been hit the hardest of any on the red list, with 297 of 744 species listed as extinct. Freshwater mussels are suffering, and there are a large number of extinctions among gastropods (snails and slugs), especially land snails that evolved in isolation on remote islands. These have been badly affected by invasive species and habitat destruction. One family endemic to Hawaii, for example, comprised 325 species in around 1900; only 18 are left.

Molluscs might just be particularly vulnerable to extinction. But if their fate is representative of other invertebrate groups, the French team estimated that up to 13 per cent of all species have gone extinct since 1500. That would make Myers's prediction of a million extinctions look about right.

Rothamsted light trap
Rothamsted Research Ltd

The main targets of light traps are moths, and Rothamsted's have been catching them in large numbers for decades. Since the insect survey began, more than 60 species have disappeared from mainland Britain, and the abundance of large moths has fallen by about a third. Remarkably, however, this loss has been more than offset by new arrivals, probably as a result of climate change. In the same period, more than 100 new species have become resident in Britain, a third of them since 2000. In terms of species richness, at least, moth biodiversity has increased.

This pattern of local biodiversity increase due to incoming species is surprisingly common, says Vellend. He has documented it in plants, another critically important group for which we don't have enough useful data. In 2013, he and colleagues published a meta-analysis of thousands of studies of local plant biodiversity from around the world. The surprise conclusion was that overall, the level of change was zero.

Planetary boundaries

In those terms, the story is one not of decline, but of homogenisation. "I don't want to give the impression that there is no biodiversity crisis," says Vellend. "At the global scale, absolutely there is. But at every other scale you can think of – continent, country, county or the small plots of land that ecologists study – the story changes because you have new arrivals. At some scales, far more non-native species have been coming in than the number of native species that have disappeared. It's hard to see that as anything other than a biodiversity increase, and that takes people by surprise."

ecological function, does that matter? What if it is replaced by two non-native ones? "That's a profound problem and it depends on what you care about," says Mace.

If you care about biodiversity per se, then it matters. The loss of a species is irreversible, and marks yet another downward tick. As species disappear, ecosystems become increasingly homogenous, with more highly successful generalists like sparrows and fewer rare specialists like Spix's macaw. But if we care about biodiversity because of the ecosystem services life provides, then one species of tree or dung beetle is very much like another.

The crucifix ground beetle
Martin Wilson/marvwilsonphotography.com. Specimen photographed at the Manchester museum

From this second perspective, how much global biodiversity loss is too much? Unsurprisingly, we really don't know. In 2009, Johan Rockström of Stockholm University, Sweden, and his colleagues started an attempt to quantify it with their concept of "planetary boundaries". They proposed there were nine support systems essential for life to flourish, including the climate, fresh water, nutrient cycles, the ozone layer, ocean pH and biodiversity.

Throughout the past 10,000 years, these systems have been remarkably stable and resilient to change, creating a benign space for civilisation to flourish. But human activity is now threatening to perturb some or all of them past a point of no return. The aim was to identify those points of no return and so define a "safe operating space for humanity".

1375
bird species threatened with extinction, 13 per cent of total surveyed

Source: IUCN Red List

In the original paper, biodiversity was measured using the most basic metric, the global extinction rate. The provisional boundary the researchers set was 10 extinctions per million species per year, around 10 times the background level. Their guess of the actual extinction rate was 100 extinctions per million species per year.

If so, that would make biodiversity the most dangerously overshot of all nine boundaries, even worse than climate change and the disturbance of the nitrogen cycle through overuse of fertilisers. But this was only a guess. Rockström's team freely admitted that the biodiversity boundary was a "very preliminary estimate", and that more research was needed to define it with greater certainty.

A few years later they came back with an answer. Out went biodiversity loss; in came something called "biosphere integrity". This was a composite of two metrics: functional diversity and genetic diversity, which supposedly reflects the biosphere's long-term capacity to withstand and adapt to change through evolution. But this, too, proved impossible to measure.

Life springs eternal

The consensus now seems to be that the boundaries approach was useful for focusing minds on what might constitute a dangerous level of global biodiversity loss. But that fundamentally it was barking up the wrong tree. "You can see from a lot of experimental work and theory that there is no boundary of biodiversity over which the functioning of the whole biosphere collapses," says Montoya. "It is not a critical transition, more like a gradual change."

Even Mace, who worked with Rockström's team on refining the estimate of the boundary, no longer sees it as a fruitful exercise. "I don't think there's a global boundary for biodiversity; if there is we're a long, long way from it. It would be to do with genetic variability or something and we're miles away from running out of genetic variability," she says.

The mistake, she thinks, comes from thinking that biodiversity can be measured one simple way. "We shouldn't expect biodiversity to be one thing, but we have to be clear about what we're trying to do."

5488
mammal species threatened with extinction, 25 per cent of total surveyed

Source: IUCN Red List

What we should concentrate on, says Mace, is local boundaries. "If we deplete biodiversity in England it has a lot of effects in England but may not affect anyone else," she says. A "safe" operating space for any local area might have so many wild species, so much forest cover and so on, to buffer us from threats such as climate change.

Despite all the uncertainties and disagreements, nobody I spoke to was in any doubt that biodiversity is in decline and that humans are to blame. But I also found optimism that the decline need not be terminal. Until a species actually goes over the brink, there is still hope we can bring it back.

"We can't reverse extinction but we can reverse abundance decline and we've done it very successfully; look at the great whales," says Mace. "A good conservation intervention can rapidly turn around population decline. There are many great examples."

Even species thought to be extinct may just be hiding. In 2008, entomologists reported the rediscovery of the crucifix ground beetle at Wicken Fen nature reserve near Cambridge. It turned out to be a case of mistaken identity, but according to Stuart Warrington of the UK National Trust, who found and then un-found the beetle, the site is big and hard to survey. "It could be there, somewhere." Hope – and life – springs eternal.

This is the first in a series of articles Graham Lawton will be writing on biodiversity across the globe. Send your suggestions for topics to cover to biodiversity@newscientist.com

Chris Thomas will be speaking about biodiversity at New Scientist Live, running from 20-23 September. For more information see newscientistlive.com/mag

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We corrected the status of the crucifix ground beetle

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