EXTINCTION IN THE ANTHROPOCENE
A CRITICAL ANALYSIS

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ABSTRACT

Anthropogenic species extinction is considered one of the planet's most pressing environmental issues, receiving widespread attention across academic and public realms. Accelerating species loss, including the idea that humans are causing the sixth mass extinction, is deemed emblematic of human impacts upon the natural world and a key signature of the Anthropocene epoch.

Although thousands of articles and books exist about extinction, it is rare to encounter a deep, reflexive account of what it is, what it is not, what it means to go extinct, and the ontological, societal, and existential implications of the current episode for humans. To flesh out these lesser explored aspects, this thesis places various facets of extinction in dialogue with each other, including scientific, anthropological, philosophical, and historical elements. I examine the scientific claim that humans have initiated another mass extinction event; the cultural history of its emergence, and how it has become a crystallising concept bringing together broader fears about the state of the planet; anthropological aspects, including the extent to which anxieties about the environmental crisis manifest as ontological concerns about the end of the world; and I explore the potential for re-imagining the extinction crisis in a way that does not simply reduce the future to loss. My primary aim is to foster a more effective cross-fertilisation and exchange of ideas between the social and natural sciences, developing better thinking, questions, and approaches toward this vexing issue.

The research is undertaken via a comprehensive literature review across numerous disciplines. My findings confirm that the sixth extinction is a speculative label unsupported by empirical science and also an inappropriate model to discuss anthropogenic species loss because of the macro-evolutionary benefits of prior mass extinctions. I also reveal that ideas about extinction have dramatically transformed over the past two centuries, driven by science but influenced by broader cultural issues. I determine that the sixth extinction and the Anthropocene constitute a crisis of modernity, the threat to which is equated with the end of the world and the biological disappearance of humans. And irrespective of whether humans are causing the sixth extinction, we are perhaps setting the stage for the 'sixth genesis' of diversity millions of years hence, when our activities could lead to unprecedented species richness.

In conclusion, I argue that extinction is a profoundly temporal and ethical phenomenon. Depending upon the prism one views the current extinction episode, it can be seen and interpreted differently. A near-time perspective confirms we are causing a 'biological annihilation' of many lifeforms, but the long-term view is that the planet is experiencing just another crisis in the history of life, and whatever humans do in the short-term will be subsumed into the deeper patterns of natural history. This suggests that concerning ourselves with the well-being of other species, beyond their value as material and cultural resources, is an issue of intraspecies ethics, involving humans 'holding open space' in the world for our non-human companions so they may diversify and resonate into the future.

EXTINCTION

IN THE ANTHROPOCENE

More than at any other time in history, mankind faces a crossroads. One path leads to despair and utter hopelessness. The other, to total extinction. Let us pray we have the wisdom to choose correctly.
— Woody Allen

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MAIN INTRODUCTION

0.1 INTRODUCTION

This opening chapter will provide all the background information to facilitate a clear understanding of what this thesis is about, an explanation of why I have done it, and how I have gone about it. It will provide an expansive description of what species extinction is, positioned within the discourse of the Anthropocene, explaining on what grounds I consider the overall topic so important. I will describe the state and size of the existing research area and why I feel it is worth writing about this most scientific of subjects from within the discipline of anthropology. I will also define my own discursive 'territory', including the knowledge gaps I believe warrant investigation, and set out my main research questions and overall aims. To provide a clear understanding of the motivations behind the study, I clarify my epistemological and philosophical position about extinction. I consider this important owing to the general sensitivity around species loss – something that for many evokes feelings of dismay and even horror – and because I will undertake a work of sharp critique. I will describe my research methods and then summarise my main findings and overall 'contribution to knowledge', speculating on who I feel might find my research helpful. In the final section, I describe how the thesis is structured, including an overview of each chapter.

0.2 WHAT IS EXTINCTION AND WHY IS THE TOPIC IMPORTANT?

As astrobiologist Aditya Chopra (2016) points out, as far as we are aware, extinction is the cosmic default in the universe and the ultimate destiny of all lifeforms. Of the estimated four billion species in the entire history of our planet, there are only millions alive today. Extinction is almost as common as origination and is one of the most basic and unassailable characteristics of life on Earth. Extinction is traditionally framed as the disappearance of species and biodiversity, but as will become clear throughout this thesis, it is scientifically, culturally, and psychologically much more than this. It is regulative and alarmist, functional and apocalyptic, regenerative and disastrous, manageable and entropic, globally permanent and locally reversible, to name but some of its many characteristics. It is, to use philosopher Timothy Morton's (2013) terminology, a 'hyperobject' that forces something upon us, something that affects our core ideas of what it means to exist, what the Earth is, and what society is.

In Darwin's classic work of evolutionary biology, *On the Origin of Species*, he defines extinction as when a species "ceases to exist" (1859:ChXI). The International Union for the Conservation of Nature similarly defines it as when "there is no reasonable doubt that the last individual has died" (IUCN 2012:14). Neither definition mentions anything about extinction being irreversible though Darwin made it clear this was at stake: "Neither species nor groups of species reappear when the chain of ordinary generation has been broken" (Darwin 1859:ChXI). Species can disappear in one of two ways. Either through gradual evolutionary adaptation to a degree they can no longer be considered the same species as their direct forbears – sometimes referred to as 'pseudo-extinction' (Sepkoski 2020) – or because all individuals die off before they can reproduce. Adaptation, comprising the combined processes of mutation and natural selection, results in both extinction and speciation – the emergence of new species. For Darwin and other scientists of his day, extinction was a positively transformative event in the process and progress of life's grandeur and something that should be welcomed. It was evidence of nature improving its stock. Clearly, this is very different from how extinction is now commonly perceived, where it evokes feelings of dismay and even horror. The changing perceptions of extinction over time are something I will investigate in detail from both societal and scientific viewpoints, including the complex interplay between them.

Mass extinction events, during which the majority of species go extinct, are much rarer than individual species extinctions. Not only do lots of species go extinct in narrow geological time windows, but lots of different kinds of species go extinct, regardless of their apparent evolutionary 'fitness'. Scientists estimate there have been as many as fifty mass extinctions over the past half-billion years (Hull 2015). However, owing to limitations in the fossil record, the exact number remains elusive. For various reasons, it is commonly believed that there have been just five geologic mass extinctions. This, however, results from identifying episodes where 75% or more of species have disappeared, rather than the so-called 'big five' having unique patterns and processes that set them apart from other lesser events (Ward 2015). Easily the most famous of these is the end-Cretaceous episode, 66 million years ago, when a giant asteroid hit the Earth and an estimated 76% of all species disappeared, perhaps in less than a year (Barnosky 2011). This catastrophe ended the reign of the dinosaurs and also created the ecological space for our ancestors to emerge. This alerts us to the paradoxical nature of mass extinctions – they are creative destructive events that have been beneficial for the evolution of complex life, including the emergence of our own genus, *Homo* (Jablonski 2005).

Some prominent natural scientists consider the anthropogenic species loss now taking place to be the sixth mass extinction, where we are entering or already inside a new extinction episode comparable to the major events in the deep past (Wilson 1992; Barnosky 2011; Ceballos 2017). This has led to some radical claims, including the suggestion that humans may push the Earth out of the Phanerozoic eon[1] and that it may be 'the extinction to end all extinctions' (Szerszynski 2016). The idea of the sixth extinction has gained significant traction within the academic and public realms and is commonly used as a framing device by articles or books describing biodiversity loss, the Anthropocene, or the environmental crisis more broadly. As I will explain, though, the term is often used indiscriminately, particularly in the social sciences, without acknowledging the scientific uncertainties surrounding such a dramatic claim, its evolutionary implications, and the ontological significance from a human, societal, and Earth-historical standpoint.

For all the concerns about the present, though, anthropogenic species loss is not, contrary to the public imagination, a recent phenomenon. As paleoanthropologists and paleobiologists have shown, large-bodied animal species have tended to die out after the arrival of *Homo sapiens* in many locations around the globe (Martin 2007), and there may have been thousands of human-caused bird extinctions on Pacific islands dating back millennia (Stork 2009). But if direct human predation caused most of these historic extinctions, current anthropogenic species loss has a much broader set of drivers that are often summarised with the acronym HIPPO, as proposed by Wilson (2002). According to Wilson, human impacts on biodiversity are due to a convergence of different and interacting factors: habitat fragmentation (forest clearance and conversion into pastures and intensive cultivations), invasive species (able themselves to cause extinctions in entire regions as well as islands and archipelagos), population growth and urban macro-agglomerates, pollution (agricultural, industrial, chemical pollution of air, water, and soils), and overexploitation of biological resources by overfishing and overhunting. In addition, there will also be non-linear interplays between the five forces. Furthermore, climate change may also result in significant ecological mismatches between species and their environments, the consequences of which are presently unclear (Moritz 2013) but which may eventually lead to countless extinctions where species are unable to adapt to their new conditions (Urban 2015).

Some of these drivers are historic and have been occurring for thousands of years, such as forest clearance (Ruddiman 2003) and intensive cultivation (Ellis 2013). Others are more recent phenomena that have emerged with increasing force over the past five hundred years in a period that, though the precise start date is contested, has been termed the Anthropocene (Crutzen and Stoermer 2000). It has been suggested that humans have now become geological agents and that our activities have become so pervasive and profound that they 'rival the great forces of nature' (Steffen 2007). As a consequence of this, particularly the activities of the past two centuries with the emergence of industrial modernity, we are now said to have

1 The Phanerozoic eon is the span of geologic time extending about 541 million years from the end of the Proterozoic eon (which began about 2.5 billion years ago) to the present. The Phanerozoic, the eon of visible life, is divided into three major time spans largely based on characteristic assemblages of life-forms: the Palaeozoic (541 million to 252 million years ago), Mesozoic (252 million to 66 million years ago), and Cenozoic (66 million years ago to the present) eras.

left the stable climatic conditions of the Holocene (Waters 2016), are living in a 'no analogue world' (Steffen 2015), and are entering a 'state shift' in the Earth's biosphere (Barnosky 2012) resulting in environmental changes not seen for millions of years, and certainly not since the emergence of the *Homo* genus 2.5 million years ago. Climate change is the most obvious manifestation of the Anthropocene since it reshapes parts of the planet where humans have not yet set foot, but biodiversity loss is another major risk scenario and, as I will describe, the issues are bound together scientifically, culturally, and discursively.

The rapid pace of extinction in the Anthropocene has led to fears of far-reaching consequences for humans and life generally, as living arrangements that took millions of years to put together are being undone in 'the blink of an eye' (Gan 2017). This includes the impact on food webs and ecosystems, the loss of resources (existing and future), the loss of diversity which will profoundly influence evolutionary trajectories, the loss of ecological interactions between species, and the vanishing of cultural anchoring points and assets (Heise 2010). The most common argument against anthropogenic extinctions is that humans are undermining their own life support systems, posing serious risks to the quality of life of humans and non-humans (Diaz 2019). Some commentators (without much in the way of analytical evidence, it should be noted) have also suggested that anthropogenic biodiversity loss prefigures a possible future event – the 'collapse of the world' and the discontinuation of humans as biological entities (Jamail 2014; Ceballos 2020; Kirksey 2015). Environmental protest group Extinction Rebellion (XR) positions the biodiversity crisis as one of mass extinction that includes the inherent threat of human extinction, where everyone and everything is 'gone forever' (image 0.1).

Culturally, species loss has translated into a profusion of popular scientific books, travel writing, films, documentaries, radio shows, theatre productions, photographs, paintings, novels, poems, and video games that address the sixth extinction, the general panorama of biodiversity loss, or the fate of individual species (Heise 2016). This identifies contemporary species loss as not solely a crisis of nature, registered by Red Lists and the actual or threatened disappearance of unique lifeforms. It is also a crisis of society. This is in terms of the way of life that has 'produced' the present situation and how it is perceived, internalised, and responded to. I suggest this marks it as fertile territory for environmentally focused social scientists to investigate and explore. However, as I will note, compared to the natural sciences, attention has been relatively minimal and only begun to emerge over the past two decades or so, driven by the burgeoning field of Anthropocene studies. This thesis is an attempt to help redress this disciplinary imbalance.

Humans may or may not be causing the sixth extinction – and as I will describe, the evidence is patchy and inconclusive – but it seems clear that collective human actions are causing, to use palaeontologist Norman Newell's (1963) phrase, 'a crisis in the history of life'. The World Wide Fund for Nature, in their assessment of 20,811 populations of 4,392 vertebrate species from around the world, showed an average 68% decline in monitored

IMAGE 0.1 Extinction Rebellion poster
Source: Extinction Rebellion (2019)

populations between 1970 and 2016 (WWF 2020). The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services predict as many as one million species face extinction in the coming decades because of human actions (IPBES 2019). They also identify extinction as an exponentially growing threat, with a third of all extinction risk emerging in the past twenty-five years alone. As we head further into the Anthropocene, many anthropogenic extinctions are still to come and without dramatic and immediate societal level action, species loss will continue to accelerate.

But if the sixth extinction and the Anthropocene are markers of the end of the evolutionary line for many species, and societally constitute a crisis of a particular world or set of world-making practices, the world usually referred to as ‘modernity’, it is also, as Wakefield (2017:6) reminds us, “a scrambling where possibility is present, and the future is more open than typically imagined”. In the catastrophic history of life on the planet and indeed the history of human societies overall, ends have usually been regenerative. The end of the world has never resulted in the end of the world full stop. As Yusoff (2019:Ch1) states, the end of the world for some can sometimes be the prerequisite for the possibility of imagining “living and breathing again” for others.

There is a discursive tendency within much environmental discourse to reduce the future to loss, catastrophe, and apocalypse where human relations with the natural world are framed as inevitably tragic and ultimately destructive. The pessimistic narratives associated with such perspectives offer both humans and non-humans alike little chance of escaping their inevitable destiny brought about by environmental decline on an ailing planet. Lovelock (2007:4) provides a vivid example of such a pre-determined viewpoint. We are, he states, “travelling on a rocky path to Stone Age existence…one where few if any of us survive the wreckage of our once biodiverse Earth”.

However, as Kohn (2013) asks, for whom is the current crisis a maelstrom? Is it the majority or perhaps even the *entirety* of life, as is popularly imagined? Not so, according to an increasing number of biologists. Evidence is coming to light that suggests human activities over the past five hundred years, in particular the human-mediated translocation of species around the world which has resulted in almost all countries, states, and islands becoming more biologically diverse than they have ever been (Thomas 2013), is potentially setting the scene for a surge in evolutionary activity that over geologic timescales may match or eventually exceed anything previously experienced over Earth history. Furthermore, for some categories of life, in particular plants, this increase may already be commencing (Suggitt 2019). Without eliding ethical concerns around anthropogenic species loss, which some consider a ‘great moral wrong’ (Cafaro 2014), this information represents an intriguing challenge to our perception of human impacts upon biodiversity and ‘nature’ overall. These, plus many other aspects of the always complex, often confounding terrain of extinction research, will be investigated over the ensuing chapters and will provide, I hope, a detailed, reflexive, and balanced exploration of extinction in the Anthropocene.

0.3 STATE AND SIZE OF THE EXISTING RESEARCH AREA

Surprising though it may seem from the present, it was not until the end of the 18th century that there was any formal recognition that species could go permanently extinct. From the Ancient Greeks through to the Enlightenment, it was thought all that disappeared would eventually return. Destruction was just a way that nature maintained and replenished itself so it could go on and create more throughout eternity (Lovejoy 1936). Consequently, extinction research of any kind only stretches back just over two centuries. However, it did not emerge in the form we recognise today until the 1970s, driven in part by public concerns about species loss as part of the burgeoning international environmental movement.

Interest and indeed formal recognition of the existence of *mass* extinctions has a much shorter history. Though French zoologist and naturalist Georges Cuvier had proposed the idea of repeated mass extinctions at the beginning of the 19th century as part of his speculations about the catastrophic history of the Earth, for reasons I explain in chapter 2, this was promptly forgotten about and did not re-emerge until the 1980s, stimulated by the startling discovery that the dinosaurs had been wiped out by a giant asteroid. Since then, research into mass extinctions and species loss more generally has grown dramatically, driven by among other things the increased availability of empirical data (in particular, the marine fossil database), international treaties such as the *United Nations Convention on Biological Diversity*, and best-selling science books, such as E.O. Wilson's (1992) *The Diversity of Life* and Elizabeth Kolbert's (2014) Pulitzer Prize-winning, *The Sixth Extinction*.

Extinction research occupies a vast intellectual landscape of theories and ideas. In the natural science realm alone, it involves palaeontology, geology, biology, molecular genetics, ecology, physics, climatology, and chemistry, among many others. Over recent years, there has been the growth of what Bambach (2006) describes as an 'extinction industry'. In the twenty years prior to 1954, the number of papers related to 'extinction in the fossil record', as determined by a keyword survey using GEOREF, was about one per year. It reached an average of 23 per year by the late 1960s, 45 per year in the early 1970s, 80 per year in the late 1970s, passed 150 per year in the early 1980s, reached 250 per year by the late 1980s, and was over 330 per year at the start of the 21st century. A search of Semantic Scholar using the search term "sixth extinction" identifies 95,000 articles, conference proceedings, editorials, and books published between the first use of the term in 1992 and early 2022. These statistics provide a snapshot of the explosive rise in extinction research from the second half of the 20th century that is nothing short of remarkable.

The emergence and growth of Anthropocene studies over the past two decades has also been dramatic, with literally thousands of published works to date. The scientific proposal the Earth has entered a new geological epoch because of human activities has become a focus of discussion across the full gamut of academic disciplines, proliferating promiscuously way beyond the confines of Earth System Science, where it first emerged in 2000. As Lorimer (2017) states, it has become a 'mega category' that serves as an umbrella term for seemingly all academic discussions about contemporary environmental issues, including species extinction. It has captured an intellectual zeitgeist and provided a label for common curiosity and anxiety about the state and future of the Earth. Notwithstanding the various debates about geological markers, Earth System changes, start dates, and the ontological significance of a human-made epoch overall, the concept highlights how human activities are all-encompassing in their variety, planetary in their reach, and significant on the timescales of Earth history.

0.4 WHY IT IS WORTH WRITING A THESIS ABOUT EXTINCTION FROM THE REALM OF ANTHROPOLOGY

As anthropologist Genese Sodikoff (2012) points out, concerns about extinction today mark a shift from the 19th century, when the extinction problem centred not on species but indigenous peoples succumbing to European expansionism. She recounts how a discourse of extinction emerged as Europeans waxed nostalgic over the 'primitive' races killed by firearms and foreign germs, as well as the more gradual effects of cultural imperialism, population displacement, and economic and social marginalisation. Europeans elegised what they perceived to be 'living relics' of their evolutionary past and regretted the violence done to cultural diversity at the imperial frontiers. It was out of this paradox of imperialist destruction and longing for lifeways that were being destroyed that the discipline of anthropology was born. Ethnography was, in part, a project to salvage the systems of knowledge and material cultures of the rapidly disappearing indigenous populations.

Extinction, therefore, has been a core element of the discipline of anthropology since its inception. But whilst anthropologists might be described as experts in the extinction of human cultures, their engagement with the biological extinction of other species is a more recent occurrence and is minimal. Except for a couple of collected volumes, *The Anthropology of Extinction: Essays on Culture and Species Death* (Sodikoff, ed. 2012) and the more interdisciplinary *Extinction Studies: Stories of Time, Death, and Generations* (Rose et al. 2017) it is fair to say that anthropological exploration of contemporary species loss is mostly a product of the past two decades, driven, I contend, by the massive interest in the Anthropocene concept. Latour (2014) has famously described the Anthropocene as a 'gift to anthropology' that is an invitation to 'renegotiate the shape, boundary, limit, and extent' of anthropology's core concern, humanity. This thesis is part of such a renegotiation that, I hope, will help us think through and confront our own precarity on the planet, centred as it is around the web of life and the loss of other species.

It has been claimed that virtually all wild animal extinctions over the past fifty thousand years are of anthropogenic origin (Martin 2007). Whether or not this is true is probably impossible to prove, but it seems clear that over the last five hundred years, with the instigation of 'Global-World-Space' (Yusoff 2019), humans have hit other species with the force of an asteroid (Nixon 2014). Anthropologist Richard Irvine (2013) has even described humans as an actual mass extinction. Regardless of whether humans have instigated the sixth extinction, it is clear we are driving elevated biodiversity loss and, in doing so, risking our own premature end. This marks the extinction of other species as a profoundly human and thereby anthropological concern and begs the obvious question of why engagement with contemporary species loss has been so insubstantial within anthropology and the social sciences more generally.

0.5 RESEARCH TERRITORY AND THE KNOWLEDGE GAPS I HAVE IDENTIFIED

As noted in the previous section, anthropological and social scientific engagement with species extinction is a recent occurrence occupying only the last two decades. Whilst biological extinction has been understood and debated for over two centuries, the ontological and societal implications of it are still being thought through and, relative to the scientific aspects, are in their infancy. This itself is a clear research gap that anthropologists, including myself in this thesis, are well-positioned to step into and investigate.

Notwithstanding the explosive growth in extinction research over recent years, political ecologist Audra Mitchell (2015) thinks that for all that is written, extinction is one of the most under-theorised, under-discussed, and under-thought-out concepts in academic discourses. Although thousands of articles and books have been produced about it, she suggests it is still rare to come across a deep, reflexive account of what extinction is, what it isn't, what it means to 'go extinct', and in the final analysis, what is at stake for humans. In other words, accounts that strive to penetrate and connect its various facets – scientific, historical, ontological, and psychological.

The underlying subtext of the scientific data about species extinctions, in particular the discourse around the sixth extinction, is that in driving other species to their premature end, humans are at risk of civilisational collapse and perhaps even their own total disappearance. As Kolbert (2014:ChXIII) vividly states in *The Sixth Extinction*, "in pushing other species to extinction, humanity is busy sawing off the limb on which it perches". But what is the empirical basis of such claims? How have scientists and journalists, including Kolbert, adjudged that we are entering or already in the sixth extinction? And if one of the suggested consequences of the sixth extinction is that humans, through their own actions are driving themselves towards an apocalyptic end, again, on what basis is the risk of such an occurrence considered possible? Both these grand claims, if true, would constitute profound moments in the biological and ontological history of the planet. It would be the first time during the Phanerozoic eon that an extinction episode has been caused by an individual species, and it would be the first time *any* species has thought upon its demise and assumed liability for its fate.

As Carl Sagan (1980) famously quipped, "extraordinary claims require extraordinary evidence". This statement is at the heart of the scientific method and a model for critical thinking, rational thought, and scepticism everywhere. The extraordinary claims of a human-made sixth extinction and consequential human self-extinction one would reasonably expect to be based on extraordinary evidence – evidence that as a matter of course is scrutinised and able to withstand the close attention of critical thinkers. However, based on my research, it is rare to find even a cursory analysis of the sixth extinction claim and almost no analysis of the claim of consequential human extinction. These claims, it would seem, are simply accepted and taken at face value despite, as I will demonstrate, the sheer indeterminacy of the science. For example, the recent Society for Cultural Anthropology Editors' Forum titled *Multispecies Care in the Sixth Extinction* adopts the term uncritically, emphasising they take the sixth extinction "as a point of departure" (Münster et al. 2021), ergo something that is neither subject to analysis nor questioned. Such an approach is not uncommon and, I contend, characteristic of much extinction and Anthropocene discourse, particularly material emanating from the environmental humanities. It also hints at how concerns about the sixth extinction are not solely driven by the absolutes of species loss and that the idea is used as a metaphor to express broader concerns about the state of the planet and the longer-term future of humanity. Analysis of these tendencies, and the history behind them, is something that has received little attention and speaks directly to Mitchell's point above about the absence of reflexive analysis and critical investigation into the deeper 'meaning' of extinction.

It is rare to find accounts of extinction that are not simply based on the idea of loss and disappearance. As Heise (2010) notes, most of the articles, books, and other cultural productions about extinction and the presumed sixth extinction are textbook examples of the rhetoric of decline. Little attention is afforded to the deep history of life on Earth and how "destruction and creation are locked together in a dialectic of interaction" (Gould 1984:18). Palaeontologists have written extensively about how mass extinctions are the engine of evolution that creates diversity (Raup 1994; Jablonski 2005), and ecologists are now documenting the emergence of 'Anthropocene biotas' (Thomas 2020; Ellis 2019) – entirely new species configurations that are emerging as a consequence of human transformations of the biosphere that may eventually result in an explosion of evolutionary activity.

Profound changes are happening all around us in the Anthropocene as macroscopic life is rapidly turned over, and codes of living that have existed for millions of years are coming undone. However, as Wakefield (2020) ponders, what happens if we try to look at these changes from a less rigid or calcified perspective and acknowledge that while the Anthropocene is a time of great change – a 'Kairos moment'[2] – when ways and forms of life are falling apart, this doesn't need to be an absolute tragedy. New possibilities are also arising and may do so increasingly into the future. Within the Anthropocene and extinction discourses and their focus on loss and tragedy, little consideration is afforded to this, even though it provides grounds for hope in the increasingly troubled present.

2 Greek has two words for time: time as Chronos indicates the successive cyclical passing of day and night, moment by moment, generation by generation; time as Kairos indicates moments in time which herald great or sudden change, or the need for change, in the flow of events and the passage of history (Northcott 2015).

This thesis is not concerned with the causal drivers of species extinction nor the deeper aspects of responsibility. Unlike climate change, the primary focus of much Anthropocene discourse, this is a more complex and sensitive issue that historically cannot so easily be attributed to capitalist modernity and its repercussions, though these are certainly a significant part of the overall picture.[3] For example, the first known species loss involving humans happened between 10-50 kya[4] during the late Quaternary period when two-thirds of all mammals above 44kg became extinct everywhere except in Africa. This event was an extinction spike exceeding all but one episode over the past 55 Myr (Koch 2006), and the loss of phylogenetic diversity has no analogue within the fossil record (Davis 2018). I do, however, engage with the debates around agency and responsibility in the Anthropocene discourse, noting their prevalence within discussions about contemporary environmental change. I also do not extensively engage with the deeper ethical aspects of anthropogenic extinction and biodiversity loss, which are significant discussion points, particularly amongst conservationists, environmental philosophers, deep ecologists, and commentators from the environmental humanities. This in no way denies the importance of such debates but for epistemological and space reasons they are mostly excluded here. I do, however, ruminate over extinction ethics within my main conclusion.

0.6 MAIN RESEARCH QUESTIONS AND AIMS OF THE STUDY

There are innumerable research lines one could pursue through the subject of extinction. It is, again to appropriate Morton's (2013) 'hyperobject' idea, something so massively distributed in time and space relative to humans that it out-scales us, escapes our comprehension, and owing to its discursive vastness is impossible to hold in mind in its entirety. Any thesis on extinction will, therefore, only ever be modest in its ambitions.

As noted above, direct anthropological incursions into biological species extinction, the sixth extinction, and the associated possibility of future human extinction have only really emerged over the past two decades. There is no substantive social scientific research base that can readily be drawn upon, nor are there obvious 'hot topics' or over-arching questions pertaining to extinction that can be expanded or developed. In that regard, it is a relatively open study area that I suggest is still being thought through within the social sciences. This makes research demanding, as it necessitates engagement with vast, cross-disciplinary literature to identify potential research gaps and opportunities. It also, however, makes things exciting. At every turn, one encounters a broad array of ideas, histories, theories, speculations, and possibilities that can be navigated and weaved to suit one's interests and research agenda.

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3 For information on the drivers of contemporary species extinctions, see Bellard (2012), Cafaro (2015), Dirzo (2014), Kiers (2010), Mace (2008), and Polaina (2018).

4 kya = thousand years ago, Mya = million years ago, Gya = billion years ago.

This thesis will critically analyse four separate but interlinked 'core' aspects of species extinction: the scientific, the conceptual-historical, the ontological, and what I term the future-anterior – actions that emanate in the past/present that will only be finished in the future. There is no single overarching research question, but the main hypothesis I will carry forward and investigate through different lines of enquiry is that extinction is as much, and perhaps primarily, a crisis of society as it is a crisis of nature and the non-human world. For the informed reader, this may sound trite, but engagement with the detail reveals some startling insights and connections that support this overall idea, many of which I believe are under-researched and have significant potential for expanded investigation in the future.

The primary research questions I will respond to by chapter are:

1) Are we in the sixth mass extinction?
2) Given the indeterminacy of the scientific data, what explains the considerable interest in the sixth extinction and species loss overall?
3) To what extent are concerns about the environmental crisis, including the sixth extinction proposition, a manifestation of ontological fears about the end of the 'modern world'?
4) If the Anthropocene and the sixth extinction are as much a crisis of thought as a crisis of life, is it possible to rethink or reimagine our collective planetary predicament that does not simply reduce the future to loss?

Notwithstanding these questions, some of the main aims of the study are to:

- Provide a deep, reflexive, cross-disciplinary account of species extinction, including consideration of the possible biological disappearance of humans.
- Provide a critical analysis of some underlying scientific and cultural ideas about extinction and the Anthropocene.
- Investigate the relationship between the cultural and scientific aspects of species loss and how they help shape perceptions of the biodiversity crisis.
- Enable a more effective cross-fertilisation and exchange of ideas about extinction between the social sciences, the natural sciences, and Anthropocene researchers.
- Bring considerations of extinction and the Anthropocene into much closer conversation.
- Inspire social scientists to engage more critically with the scientific material on extinction and not simply accept scientific claims at face value.
- Provide a 'thick description' (Geertz 1973) of the key scientific aspects of extinction research, something no anthropologist, to my knowledge, has attempted.

- Inspire anthropologists to move away from narrow, human-centred time perspectives when considering relations with the natural world towards geologic, 'zoecentric' (Chakrabarty 2015) thinking, more attuned to the deep history of planetary life and processes.
- Help develop an environmentally focused anthropology that is more able to face the ecological crisis.
- Investigate whether the sixth extinction is an appropriate model for talking about the biodiversity crisis, noting that palaeontologists identify mass extinctions as the major engine of species diversification over the past half-billion years.
- Piece together the history of extinction research from its inception in the late 18th century to the present, mapping its movement over time.
- Investigate the possibility of the extinction of *Homo sapiens*, something often alluded to within extinction discourses, but which receives little detailed analysis.
- Investigate some of the ontological aspects of extinction, something I contend is still being thought through within extinction research.
- Examine how perceptions of nature and the natural world impact responses to the biodiversity crisis and the Anthropocene.
- Examine if there are any upsides emanating from the biodiversity crisis that are marginalised or omitted from the popular discourses and which challenge the dominant environmentalist narrative of the Earth in decline under human activities.

0.7 EPISTEMOLOGICAL AND PHILOSOPHICAL POSITION IN RESPECT OF MY RESEARCH

A key point to make before entering the main body chapters of this thesis is that whilst this work is a critique of some of the discourses of extinction, including the scientific aspects, I am neither denying nor underplaying the seriousness of the biodiversity crisis. The trend toward higher extinction rates is not in doubt and it is also incontestable that humans as a whole bear responsibility for the majority, if not all, of them. As Ceballos (2017) has notably proclaimed, we are amid a "biological annihilation" of many forms of life. One only needs to attend, for example, to tropical deforestation rates over recent times to confirm this is the case (Achard 2014). Whether this is tipping us into the sixth extinction is another matter and something I will examine in detail.

Extinction is a normal part of evolutionary processes, something known, though arguably now forgotten, since Darwin's day. It has been occurring for billions of years, since the start of life on the planet, as the counterpart to the emergence of new species. Reading many popular academic and journalistic articles on extinction, one would never really know this. The inextricable relationship between extinction and speciation and how the former historically results in the latter is generally underplayed or omitted altogether. Equally, the role of mass extinctions in the evolution of complex life and ecosystems is similarly under-communicated within most discussions on the sixth extinction. I contend that both these tendencies, intentionally or otherwise, fail to convey the broader implications of extinction based on what we know from the history of life.

As discussed at the start of this introductory chapter, there are unambiguous widely accepted operational definitions of what constitutes species extinction, and they all agree on the same principal fact: species go extinct when the last existing member dies somewhere on the planet and there are no surviving individuals that can reproduce and create a new generation. This key, apparently simple, but often misunderstood fact is the starting point for any discussion about biological extinction. Extinction is not when a species disappears from a particular area, region, or continent – something that has its own scientific term – extirpation.[5] Neither is it when a species goes extinct in the wild but remains alive somewhere in captivity.[6] Extinction, in a genetic sense at least, is when a species 'ceases to exist' (Darwin 1859). Without wishing to dismiss broader uses of the term, particularly as I will explain in respect of human self-extinction where the meaning is opaque, I will endeavour to stay as close to the commonly accepted scientific definition as possible. I believe this is important so that the concept and overall use of the term do not become what Mitchell (2017) describes as an 'empty superlative gesture' used to talk about general anthropogenic impacts upon biological life.

Notwithstanding this, it is fully recognised that extinction is never simply a genetic or scientific event. It is always a multi-contextual phenomenon requiring multi-disciplinary modes of encounter and understanding (Wolfe 2017). No single discipline can provide all the answers to its myriad questions, and it follows that 'departmental thinking' (Chakrabarty 2015) where researchers stay 'in discipline' – in my instance, anthropology – would be as futile as it would be inhibitory. This clearly makes it complex for any researcher trying to attain a detailed understanding of what extinction is, what it means, why it is important, etc. The position I hold, therefore, is that it is necessary to embrace material from a broad array of academic disciplines mostly, it should be noted, from outside of anthropology. This is because, as stated, most of the discourse on extinction emanates outside the social sciences, but also because many anthropologists who engage with extinction often fail to relate to its scientific fundamentals.

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5 For geographer Ben Garlick (2020), the notion of 'extirpation' as something separate from 'extinction' is problematic. It does, in his opinion, create the risk of rendering life as fungible and exchangeable across its dynamic spatiotemporalities by arguing that a loss is only permanent (an extinction) if the species as a whole is eradicated across its geography in entirety. In such a narrative, place is a mere background, reduced to interchangeable habitat. Whilst I broadly concur with the overall thrust of his position, he is making separate arguments, contesting the prevalent meaning and implications of a widely accepted scientific term and how it inadequately represents both the impacts of the phenomenon it is trying to describe and how it is experienced. This will be discussed further in my main conclusions.

6 I recognise there are philosophical arguments that such species are ontologically extinct and thereby extinct in some sense of the word. See Van Dooren, Thom. 2014. Flight Ways: Life and Loss at the Edge of Extinction. Columbia University Press.

If anthropology is 'thick description' (Geertz 1973) that seeks to interrogate dominant modes of knowledge (Tsing 2015) then this approach to writing and research does not, I contend, extend to extinction studies. Having reviewed the literature, it is clear that many anthropologists and social scientists do not substantively engage with the scientific material on extinction. This is particularly evident in respect of the sixth extinction, which has been embraced uncritically within the realm of anthropology[7] and is often used casually to express more general ideas about extinction or other environmental issues. This is not to suggest there can only be one 'securitised' definition of what extinction is. However, it does suggest that if one is utilising scientific terminology or grand propositions such as the sixth extinction claim that emanates from the natural sciences to develop academic arguments, one should do so in an informed manner. If not, there is a risk of undermining the points one is trying to make.

0.8 HOW I HAVE CONDUCTED THE RESEARCH

Anthropological practice usually comprises two intimately linked processes of fieldwork (participant observation) and writing (Hastrup 1990). Anthropologists go out to the field, undertake ethnography, and then write about it to 'produce' anthropology. However, this conventional, tried-and-tested approach is not one I have adopted in this thesis. There are two main reasons behind this. First, I am a self-funded, part-time student who did not have the financial means to undertake 12-18 months of full-time self-supported ethnographic fieldwork. My original PhD proposal involved investigating biological and cultural extinction in Western Amazonia, working with indigenous groups along the Purus River in Peru, where I was hoping to secure funding to spend time in the region. Unfortunately, and for several reasons, mostly cost-related, this proposition was not viable. Second, over time, my research focus has changed. The emergent area of Anthropocene studies, which I began to engage with from late-2013 following my attendance at a two-day conference in Paris, *Thinking the Anthropocene*,[8] transformed my ideas about extinction, stimulated by the profound implications of the proposed new human-made geological epoch. As Rowan (2014:447) notes, "The Anthropocene is…a philosophical event that has struck like an earthquake, unsettling the tectonic plates of conceptual convention". The epistemological implications of the Anthropocene are too broad to discuss within the confines of an introductory chapter (though I will discuss them eventually) but suffice to say whereas anthropology is conventionally locked-in to narrow, human-centred time periods, something Irvine (2020) describes as 'presentism', the Anthropocene and its discontents necessitate engagement with much longer geological timeframes, including the long history of life on the planet.

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7 See, for example, Rose (2011), Irvine (2020), Münster et al. (2021).

8 The conference programme and further details can be found at https://gemenne.files.wordpress.com/2013/11/thinking-the-anthropocene-final-programme.pdf

Extinction similarly necessitates such a 'deep time' perspective, something I was mostly unaware of when I drafted my original doctoral proposal. I now realise that only through a penetrating engagement with the history of life on Earth can any sense be made of it, not least because the interlinked destructive and creative aspects of extinction operate at different timescales. Destruction can be instantaneous in geological terms, recovery less so. Also, extinction, I believe, does not so easily lend itself to ethnographic enquiry within the narrow time constraints of a UK PhD programme. As will become apparent over the proceeding chapters, it is too vast, too complex, and there is so much to take on board before one can realistically undertake informed fieldwork. This is not to suggest one cannot research the topic ethnographically (something I will discuss further during the main conclusion), but rather whereas anthropological practice normally involves the processes of fieldwork and then detailed analysis in that order, I am arguing that for a proper anthropological study of extinction, it should be the other way around. In other words, to do the ethnography, one first needs to undertake an intense, critical anthropological analysis of the broader subject of extinction.

For practical as well as intellectual reasons, therefore, this is a desk-based study. I engage with scholarship from the realms of Anthropocene studies, palaeontology, evolutionary biology, anthropology, resilience theory, existential risk, geology, science and technology studies, cultural studies, environmental history, conservation biology, philosophy, astrobiology, climate change, human geography, and no doubt many others. Much of this material was completely new to me, discovered through extensive and no doubt inefficient years of reading. The work is an exercise in what Scott (2017) describes as 'trespasser reconnaissance' into unfamiliar disciplines, and the resultant output is, to evoke Lévi-Strauss (1966), 'bricolage' where I have attempted to create something original, incisive, and scientifically grounded, pieced together from a diverse range of sources and data.

To manage the sheer volume of material, I prepared an extensive keyworded and searchable database of over five hundred reference sources – books, journal articles, conference proceedings, reports, magazine pieces, and documentaries. I also 'mind-mapped' the research data to identify connections between the various discourses. Another important aspect of my research process was ongoing discussions with my supervisor, Miguel Alexiades, directly and through our long-standing reading group, *Anthropocene Exploratory*,[9] that we have co-hosted over the past few years at the University of Kent School of Anthropology and Conservation, both in person and now online, where we have attendees from a range of disciplines (image 0.2). Through these discussions, I was able to develop a research pathway through the material.

9 See https://anthropoceneexploratory.wordpress.com

IMAGE 0.2 Anthropocene Exploratory spring 2021 poster
Design by Anthropocene Exploratory / Carolina Vargas

0.9 MAIN FINDINGS AND OVERALL CONTRIBUTION TO KNOWLEDGE

A vast amount of research has gone into this thesis, spread across many years, involving hundreds of information sources from a variety of disciplines. Every turn has been a learning experience where I have acquired new knowledge that has repeatedly strengthened my interest in extinction and Anthropocene studies. Overall, I now have a much fuller understanding of global environmental change than before I commenced the PhD programme and feel I am in a solid intellectual position to judge the strengths and weaknesses of what I have produced.

My biggest achievement, and what might be described as my primary 'contribution to knowledge' to use the hackneyed phrase, is, I believe, the production of a deep, reflexive, and critical review of extinction research where I have carefully and selectively synthesised discourses from an array of disciplines to answer my research questions. I have appraised, connected, and interrogated countless research lines, including scientific, philosophical, anthropological, and historical, and placed them in direct conversation with one another in a way I believe is original, engaging, informative, and empirically robust. Realistically, it is probably at the behest of experts from the fields of extinction and Anthropocene studies to assess the ultimate merits of what I have done. However, based on my extended immersion in the literature, I believe some of my findings and observations are intellectually sound and original and, in certain instances, warrant further exploration. I will say more about this in my main conclusions.

The main findings and observations from my research are:

General

- Anthropological engagement with biological species extinction is limited relative to other disciplines.
- There is a systemic flaw in social scientific engagement with extinction, specifically the proposal of the sixth extinction, that is commonly accepted uncritically, without acknowledging the many uncertainties and complexities surrounding such a grand claim.
- Notwithstanding the clear scientific definitions of what constitutes extinction, it is used by different authors in different ways to express different ideas. This sometimes results in researchers talking at cross purposes from one another, leading to what has been termed 'uncontrolled equivocations', "a type of communicative disjuncture where the interlocutors are not talking about the same thing, and do not know this" (Viveiros De Castro 2004:7).
- The extinction crisis is a planetary-scale phenomenon, whereas the methods of anthropologists are suited to studies of local, community-scale processes and events. Also, anthropologists conventionally focus on near-time analysis within human-centred timescales, whereas extinction is an inherently temporal phenomenon necessitating analysis over geologic timescales. This raises the open

question of whether anthropology's traditional methods lend themselves to the study of extinction.

Chapter 1

- Very little is understood about species extinction, particularly mass extinctions, despite the significant academic and public attention over the past fifty years.
- The sixth extinction proposition is a speculative label currently unsupported by empirical science. There is not enough data to affirmatively make such a declaration.
- The sixth extinction is an inappropriate model to talk about anthropogenic biodiversity loss. This is because over geologic timescales, mass extinctions have been creative destructive events that have normally led to increased species richness over time. Over the past half-billion years, they have been the engine of macroevolution and the ongoing development of complex life.
- Regardless of whether humans are initiating the sixth extinction, they are causing a structural reordering of life on our planet and the 'biological annihilation' of innumerable macroscopic lifeforms.
- Environmentally focused social scientists engaging with extinction often fall into what has been described as 'scientism' (Clark and Szerszynski 2020) and accept natural science information uncritically.

Chapter 2

- Recognition of extinction has only occurred over the past two hundred years and awareness of mass extinctions only over the past forty.
- Ideas of extinction have changed dramatically over time. They have transformed from being totally denied, accepted, welcomed, to being something many now view with dismay and horror.
- Though these transformations have mostly been driven by scientific developments, including Darwin's theory of evolution in 1859 and the discovery of geological mass extinctions in the 1980s, they have also been influenced by other factors. This includes religious beliefs, global events such as the Cold War, growing awareness of human impacts on the natural world, and existential anxieties about the longer-term future of humanity.
- In recent years, extinction has become a crystallising concept, bringing together many of the broader environmental concerns about the state of the planet, including the possibility of omnicide – human self-extinction.

Chapter 3

- Extinction is a crisis of society as much as a crisis of nature.
- The sixth extinction proposition and wider ecological concerns about the

state of the planet as they manifest within the Anthropocene discourse can simultaneously be interpreted as an expression of ontological concerns about the collapse of the 'modern way of life'. Or, to phrase things differently, the collapse of the 'modern world'.

- Extinction, particularly the idea of the human-caused sixth extinction, has become an emblem of Western fears about the end of their world.
- It is often asserted or implied within Anthropocene and extinction discourses that humans are pushing themselves towards self-extinction. Such claims are made without any substantive foundation.
- Fears about the 'end of the world' have been recurrent throughout recorded history across most cultures.
- The obsession with saving the modern world and the reluctance to accept it may soon end or is perhaps already over inhibits a proper engagement with the 'new world' conditions of the Anthropocene, where humans risk becoming ontologically 'locked-in' to the past, unable to face the future.
- Existential risk researchers have identified a one-in-six chance of human extinction over the next century. However, it is unclear what they mean by 'human extinction'. Though there is typically little confusion about what the extinction of other species means (human-induced or not), fears about human extinction cannot simply be interpreted as the discontinuation of humans as biological entities. Extinction also, and perhaps mostly, seems to mean extinction in an ontological sense.

Chapter 4

- Human relations with the natural world in the Anthropocene are commonly framed as tragic, with the future reduced almost entirely to loss. The openness, contingency, and projections about other future possibilities have been closed off in favour of a singular, loss-based, deterministic view.
- Perceptions of the Anthropocene and the extinction crisis are strongly influenced by the perception that the natural world is 'deanimated'. This has a long history in Western thought and has been foundational to the project of Western modernity.
- Parts of nature are responding reasonably well to anthropogenic disturbance in the Anthropocene, occupying and exploiting new ecological niches created by humans via their transformative activities.
- It is rare to find any discussions on the sixth mass extinction and the biodiversity crisis that balance both sides of the biological equation, emphasising the loss without ignoring the species gains occurring in the present and probably the future.
- Regardless of whether humans are causing the sixth extinction, they may also be setting the stage for the 'sixth genesis' of diversity millions of years in the future, something I experimentally describe as the 'sixth extinction back loop'.

0.10 WHERE MY RESEARCH SITS AND WHO MIGHT FIND IT USEFUL

As noted, there has been relatively little anthropological engagement with contemporary species extinction or research into human extinction, so in the first instance, this thesis should be a welcome addition to the discourses of environmental anthropology and other environmental-social science disciplines. It will be helpful for researchers who may want a better understanding of extinction science, including mass extinctions, the cultural and discursive history behind it, and how it maps onto broader societal fears about the future of humanity. Natural scientists may similarly find these latter societal aspects useful.

In terms of where my project sits epistemologically, I suggest it might best be located within the emergent 'environmental humanities' research field. Though it is not yet fully clear what the environmental humanities are or will become (Rose 2012), they can perhaps be understood as a useful umbrella bringing together many sub-fields of environmental studies that have emerged over the past few decades, facilitating new conversations between them. This includes academics from environmental literature, environmental philosophy, environmental history, science and technology studies, environmental anthropology, and environmental communication. The environmental humanities may also be thought of as challenging the convention or idea of independent disciplinary fields of enquiry, functioning as a provocation toward a more interdisciplinary set of interventions directed toward some of the most pressing issues of our time (Heise et al. 2017).[10] As will become apparent, extinction research commands such collaborative approaches.

0.11 HOW THE THESIS IS LAID OUT

The thesis is arranged over four main chapters of about fourteen thousand words each. The chapters are closely interlinked components of an overall narrative incorporating a careful selection of some of the scientific, historical, ontological, and more speculative aspects of this vast terrain of thought.

In chapter 1, I undertake a review of the scientific data, investigating the widely held belief humans have initiated the sixth mass extinction of species, "rushing to eternity a large fraction of our fellow species in a single generation" (Wilson 1992:32). Such a claim is, I contend, often accepted uncritically by social scientists. But as I explain, scrutiny of the scientific data around geologic mass extinctions and contemporary anthropogenic extinctions reveals significant uncertainties about almost every aspect. This leads me to query the validity and wisdom of making such a grand claim and, due to the inherent complexity, whether it will ever be empirically possible to fully gauge the human impacts on the biological life of the planet.

In chapter 2, I investigate why the sixth extinction and general concerns about biodiversity loss have gained so much traction over recent decades across multiple realms – academic,

10 For further details on the Environmental Humanities, see Heise, Ursula, Jon Christensen, and Michelle Niemann, eds. 2017. *The Routledge Companion to the Environmental Humanities*. Routledge.

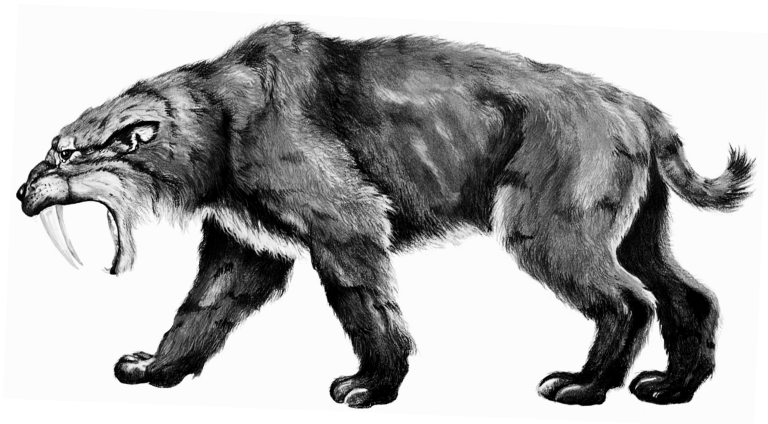
journalistic, creative, and many others. I describe how interest in the sixth extinction has been driven by a whole suite of factors, including scientific advances, ideological changes, global events, changing perceptions and understanding of the natural world, and existential anxieties about the future of humanity. I identify how the sixth extinction proposition from the onset has been a crystallising and catalysing concept, bringing together broader concerns about the state of the planet, including the possibility of human omnicide. Also, I detail how perceptions of extinction have continually changed over time, sometimes dramatically, confirming it as a profound social and scientific issue.

In chapter 3, I further probe the social and cultural aspects of extinction, bringing it closer to the familiar territory of anthropology. I will explore the notion that the sixth extinction proposition and the broader ecological concerns about the state of the planet as they manifest within the Anthropocene discourse can also be interpreted as an expression of ontological concerns about the collapse of the modern way of life and the modern world. Whilst it is difficult to argue that the environmental situation humanity finds itself in is not a crisis of nature, it is also, and arguably primarily, a crisis of society. These separate but related crises result in what Lear (2006), in another context, has described as 'ontological vulnerability'. Confronted with the possibility of the sixth extinction and the arrival of the Anthropocene epoch, I investigate the idea that our collective ecological vulnerability on the planet ushers in our ontological vulnerability.

In chapter 4, I will engage with the biological and ecological conditions of the sixth extinction and the Anthropocene in a way that extends beyond simple narratives of devastation and loss. I explore the possibility of re-articulating the biodiversity crisis as not just a time of 'hyper catastrophe' (Bińczyk 2019) but also a time of emergent opportunity where the future is more open than is popularly imagined and hope is still present. By adapting ideas from resilience theory, critiquing prevalent perceptions about 'nature', and analysing scientific data on species movement and novel ecological configurations in the Anthropocene, I will offer, in part at least, a counter-vision to the dominant loss narrative within environmental discourses. I ultimately suggest that if humanity wants to be optimistic about the future, the sixth extinction needs to be actively 'inhabited' with full acknowledgement of the unintended biological opportunities that will likely arise from it. To do otherwise, I suggest, would fail to recognise the inherent dynamism of planetary life and its capacity to respond to whatever challenges and opportunities it encounters.

I conclude by suggesting that extinction is a profoundly temporal phenomenon that provides an ethical puzzle for humans. Whatever we do in the short-term will, in time, likely subsume itself into the deeper long-term patterns of natural history. The Earth will one day forget us, and our geological and evolutionary trace will probably be minimal. However, such a view does not recognise the deep cuts humans are making into the ecologies of life in the present and the ongoing deaths of countless species and populations, many of whom are unknown and unseen. Following Van Dooren (2014), humans are, I suggest, ethically obligated to hold open space in the world for other species, commanded to do so by the entire multi-billion-year history of life on the planet.

To close, I provide details on the limitations of the thesis, some of which are unavoidable, others that result from personal decisions. I also make suggestions for future research directions, including the possibility of opening my own research to ethnographic enquiry.



CHAPTER 1

ARE WE IN THE SIXTH MASS EXTINCTION?

> Right now, we are in the midst of the Sixth Extinction, this time caused solely by humanity's transformation of the ecological landscape. (Central exhibition plaque, American Museum of Natural History's Hall of Biodiversity 2013)

> From the perspective of geological time, Earth's richest biota ever is already well into a sixth mass extinction episode. (Ceballos 2017:E6089)

> We are in the midst of a mass extinction event; indeed, we are a mass extinction event. (Irvine 2013:129)

> The extinction rate our behavior is now imposing on the rest of life, and seems destined to continue, is more correctly viewed as the equivalent of a Chicxulub-sized asteroid strike played out over several human generations. (Wilson 2016:Ch19)

1.1 INTRODUCTION

The idea that humanity has initiated the sixth mass extinction of species has received significant academic, journalistic, and public attention. Popularised by the likes of Elizabeth Kolbert's 2014 Pulitzer Prize-winning book, *The Sixth Extinction*, and widely publicised international reports such as the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services' recent *Global Assessment* (IPBES 2019) which estimated one million species are at imminent risk of extinction, it has been taken up by numerous natural and social scientists and has had widespread crossover into the public realm.

The sixth extinction idea now forms part of the broader Anthropocene narrative of the Earth radically transformed by human activities over recent millennia. It has been claimed that in terms of our impacts upon the planet, humans are now operating with a force equivalent to that of an asteroid (Nixon 2014). This is a direct reference to the end-Cretaceous mass extinction event, 66 million years ago, when a giant impactor crashed into the Earth, causing an estimated 76% of all species to disappear (Barnosky 2011).

If the sixth extinction proposition is correct, it would be a moment of profound ontological significance, dramatically scaling up our imagination of the human (Chakrabarty 2009). It would be the first time in the known history of complex life that an individual species has caused a mass extinction; the first time a mass extinction has been primarily driven by biotic forces; and it would ultimately designate humans as geological agents, confirming the suggestion that our activities in their scale and influence “now rivals some of the great forces of Nature” (Steffen 2011:843). A key stratigraphic signature, therefore, of the arrival of the Anthropocene.

With all this in mind, in this chapter, I will endeavour to appraise the scientific claim that we are entering or are already in the sixth mass extinction of species. Such a proposition, I suggest, is often accepted uncritically by scientists, particularly social scientists. But as I will demonstrate, scrutiny of the scientific data reveals uncertainties about many aspects, throwing into doubt the accuracy of such a grand claim. My review reveals knowledge gaps, assumptions, and extrapolations that on a fundamental level, render many of the findings about prior mass and present-day extinctions inconclusive. This makes it extremely difficult, if not impossible, to understand the scale of present-day losses relative to those in the Earth’s deep past.

The chapter commences with a discussion about mass extinctions in Earth history. Clearly, any proper discussion about the proposed sixth extinction can only proceed with an understanding of prior events. This inevitably diverts us away from human-centred timescales and temporalities (the traditional territory of the social sciences), necessitating consideration of the long history of life on Earth. I will describe the key characteristics of mass extinctions, including how they differ from extinction patterns under natural selection, their unpredictability in terms of the species they affect (dominant incumbents are as likely to go extinct as marginal players), their regularity (palaeontologists have identified as many as fifty mass extinctions over the past half-billion years, regularly spaced over geologic timescales), their causes (still mostly unknown), their effects (notably, their positive longer-term macroevolutionary impacts), and how they are identified via an extremely limited fossil record. This will reveal there is much that is unknown or indeterminate about prior mass extinctions. Considering this, I query whether there is sufficient knowledge to use them as analogues to assess the scale of current species loss.

Next, I will discuss anthropogenic extinctions, beginning with an overview of the sixth extinction proposition. I will explore the pertinent extinction science, describing the key variables needed to gauge the intensity of the present-day extinction episode: the number of species on Earth (currently unknown), the background or ordinary rate of extinction over geologic timescales (not agreed upon, with a 1000% disparity between the estimated upper and lower amounts), and the current rate of disappearance of species (mostly unknown). I will describe how there is uncertainty around each variable, centred around major data deficiencies, and show the sheer amount of guesswork underlying current estimates and projections of species loss, even within the most widely cited scientific publications.

Key components of all debates around extinction are the related concepts of ‘biodiversity’ and ‘species’. I will describe how despite their centrality to discussions, there is still no agreed definition for either concept, with over twenty separate formulations for each. This further complicates our understanding of the number of species on Earth and the fundamental issue of how humans categorise and quantify life. It also calls into question how practices such as conservation are assembled and operationalised in response to perceived anthropogenic impacts upon the life of the planet.

There will then be a discussion where I collate key points from the preceding sections, ruminating on the robustness of the claims that we are in or entering the sixth extinction. This will lead me to question the extent to which much of the extinction science can be considered *ex-ante* authoritative. Does the data meet the criteria of reliable science, or does it mostly constitute guesswork centred around very limited datasets, wrapped in the cloak of scientific respectability?

I will conclude by stating that owing to fundamental information deficiencies, any assertions that we are in the sixth mass extinction are highly speculative and without strong empirical foundation. I argue that any such claims should be used cautiously, not least because mass extinctions in Earth history have been creative destructive events that, whilst devastating, have ultimately been beneficial for the evolution of complex life, including the emergence of humans. Also, by evoking the deep past, which any discussions on mass extinctions implicitly do, there is a risk of naturalising catastrophic environmental change as a regular occurrence over Earth history, distracting us from the real impacts that humans are having upon the biological life of the planet.

Finally, a general note to the reader that the scientific aspects of this chapter may, on occasion, be challenging. Extinction science is often very complex, involving theories and terminology spanning a range of disciplines. It is also information-heavy, using large, diverse datasets and computer modelling techniques. Simplification, as I've endeavoured to do whenever possible, works to a point, but stepping into the complicated heart of extinction research is unfamiliar ground for many social scientists and, thereby, inherently challenging. This, I speculate, may help explain why they often take the natural science data about species loss at face value rather than submitting it to detailed scrutiny.

1.2 MASS EXTINCTIONS IN EARTH HISTORY

1.2.1 The end-Cretaceous event

Sixty-six million years ago, the dinosaurs and other animals living in the Yucatán Peninsula in what is now Mexico were one day startled by a blinding flash of light across the sky. Minutes, or maybe seconds later, a giant asteroid smashed into the Earth, obliterating the surrounding area and dramatically changing life on the planet forever. Weighing an estimated hundred trillion tonnes, with a diameter of 11-81 km, it struck the Earth at around 50 km per second, generating a pressure that heated the air beneath to temperatures five times hotter than the sun. Yet it was so massive that by the time it reached ground zero in the Gulf of Mexico, the atmosphere hadn't made a scratch on it (Schulte 2010).

It is hard to conceive the force of the impact. Two million times more powerful than the Tsar Bomba, the largest nuclear weapon ever exploded, 500,000 times bigger than the 1883 eruption of Krakatoa, the energy released was equivalent to 100 million megatons of TNT. This is about 10,000 times the combined power of the entire nuclear arsenal at the height of the Cold War (Brannen 2018). When the bolide struck, a crater 40 km deep and 180-200 km wide formed instantaneously in the Earth's crust, puncturing the mantle. A fireball of 20,000 degrees Celsius vaporised almost every living thing within hundreds of kilometres and likely caused severe heat stress and death thousands of kilometres away during the proceeding hours and days. It also triggered earthquakes and tsunamis around the globe, penetrating up to 20 km inland (Sepkoski 2020).

IMAGE 1.1 An artist's representation of the asteroid that hit the Earth, 66 million years ago
Source: *The New York Times* (February 5th, 2021)

However, this was just the beginning of the ensuing devastation. The impactor injected 50,000 m^3 of ejecta, 100-500 Gt of sulphur, and 435 Gt of CO_2 and other red-hot volatiles into the atmosphere from the marine carbonate and anhydrite target rock of the crust (Hull 2015). In the years that followed, nitrogen and sulphur vapours combined to form nitric and sulphuric acids that acidified the oceans. The soot and dust blocked out the sun for months, and photosynthesis stopped completely. Even after the skies cleared, the enormous amount of CO_2 released by the limestone from the Earth's crust caused massive greenhouse gases that lasted thousands of years. The planet's ecosystems and biogeochemical processes were transformed, and the scale of the biological turnover was almost unprecedented in Earth history. Many major animal groups disappeared, including non-avian dinosaurs, marine and flying reptiles, and ammonites. It devastated several other groups, including planktic foraminifera, calcareous nannofossils, and land plants (Schulte 2010) and almost every land mammal over 25kg was wiped out (Brin 1983). By the time the Cretaceous-Palaeogene extinction (aka, the end-Cretaceous event) had played itself out over the ensuing millennia, 76% of all species are estimated to have gone extinct (Braje 2013).

There are counter-theories speculating that the end-Cretaceous mass extinction may have been caused by a combination of incidents in the hundreds of thousands of years before the asteroid impact such as lava and gas eruptions in the Deccan area of western India that caused global warming (Keller 2012), and/or tectonic uplift contributing to ocean eutrophication and anoxic episodes (Barnosky 2011). However, the strongest evidence and indeed the majority of scientific opinion suggests the Chicxulub impactor (named after the town near where it was discovered in Mexico) triggered the mass extinction event that marks the boundary between the Mesozoic (middle life) and Cenozoic (new life) eras of the ongoing Phanerozoic eon.

Younger

Eon	Era	Period		Epoch	
Phanerozoic	Cenozoic	Quaternary		Holocene	Today
				Pleistocene	11.8 kya
		Neogene		Pliocene	
				Miocene	
		Paleogene		Oligocene	
				Eocene	
				Paleocene	
	Mesozoic	Cretaceous		~	66 Mya
		Jurassic		~	
		Triassic		~	
	Paleozoic	Permian		~	252 Mya
		Carboniferous	Pennsylvanian	~	
			Mississippian	~	
		Devonian		~	
		Silurian		~	
		Ordovician		~	
		Cambrian		~	
Proterozoic	~	~		~	541 Mya
Archean	~	~		~	2.5 Gya
Hadean	~	~		~	4 Gya
					4.54 Gya

Older

TABLE 1.1 The geologic time scale
Adapted from Hendricks (2021)
There will be recurrent references to geologic timescales throughout this thesis, which is an inevitability with any engagement with deep time. At the onset, it is therefore, appropriate to provide a table that identifies the various eons, eras, periods, and epochs of the stratigraphic record. Particular attention is drawn to the Phanerozoic eon (Ancient Greek, meaning 'the time of visible life') covering the past 541 million years. It is within this eon that most of this thesis' discussions will be focused. Missing from the time scale is the Anthropocene, yet to be formally ratified by geologists as a new epoch.

The hypothesis of the end-Cretaceous impactor was proposed in 1980 by experimental physicist Luis Alvarez who discovered evidence in well-preserved sections of the Cretaceous-Paleogene boundary at the precise stratigraphic position where the dinosaurs disappeared from the fossil record (Alvarez 1980). Though at this point, the actual impact location was completely unknown and wouldn't in fact be confirmed as the Yucatan peninsula until the 1990s, Alvarez's proposal caused a sensation (Sepkoski 2020). It eventually resulted in the first scientific consensus on the occurrence of mass extinctions in Earth history and led to the transformation of long-standing ideas in evolutionary theory. These will be discussed in greater detail in chapter 2 within a longer history of extinction research. However, at this point suffice to say it was a major scientific discovery that sent shockwaves through palaeontology and evolutionary biology and captured the attention of the world's media.

Alvarez's hypothesis also triggered an explosion of activity in scientific circles that led to a series of rapid developments in extinction theory. In 1982, palaeontologists published a paper claiming that "A number of mass extinctions have "reset" parts of the evolutionary clock during the Phanerozoic" (Raup and Sepkoski 1982:1501). This was a significant advancement of Alvarez's ideas – not only had there been a mass extinction at the end-Cretaceous boundary 66 Mya (as Alvarez had implied), but they were making an explicit scientific claim there had been other mass extinctions, clearly visible in the fossil record. They identified at least five major episodes but left the door open for the possibility there may be many more.

1.2.2 What is a mass extinction?

There are multiple definitions of mass extinctions, each with its own level of complexity depending upon the intended audience. They all incorporate the idea of species or higher-order life disappearing quickly. Sepkoski defines a mass extinction as "any substantial increase in the amount of extinction (i.e., lineage termination) suffered by more than one geographically widespread higher taxon during a relatively short interval of geologic time, resulting in an at least temporary decline in their standing diversity" (Sepkoski 1986:78). The Oxford Dictionary of Biology defines them as the "extinction of a large number of species within a relatively short interval of the geological time scale" (Hine 2018). For Jablonski, they can be taken as substantial biodiversity losses that are "global in extent, taxonomically broad, and rapid relative to the average duration of the taxa involved" (Jablonski 1994:11). There are at least a couple of problems with these brief definitions. Firstly, it is not clear what 'short' means in a geologic sense. Secondly, and as I will describe below, mass extinctions are not simply identified by lots of species going extinct at the same time. Their characteristics are far more unique and extensive.

1.2.3 What are the main characteristics of mass extinctions?

Mass extinctions are global hecatombs under which entire classes of biodiversity fall (Pievani 2014). Not only do lots of species become extinct in narrow geological time windows, but lots of different kinds of species go extinct, regardless of their apparent evolutionary 'fitness'. They are mysterious, little-understood events, and it is only over the past forty years or so, after two centuries of speculation, that they have been formally recognised as bona fide occurrences and comprehensively studied.

Despite their mystery, scientists have identified several 'key' characteristics that set them apart from regular patterns and periods of extinction over geological time. All are the subject of ongoing debate and uncertainty, and each suffers from epistemic limitations owing to a chronic lack of representative data. Despite the uncertainties, it seems clear that if want to understand the characteristics and intensity of the current extinction episode (the proposed sixth extinction), we must have a grasp of the patterns and processes of prior events, including the limitations of our existing knowledge.

1.2.3.1 Mass extinctions are rare

Through an analysis of marine fossil genera, Raup (1986) estimates there have been potentially twenty-nine mass extinctions over the past half-billion years or so. More recently, Bambach (2006) placed the number at eighteen, but there have been estimates as high as fifty (Hull 2015). Nowadays, the term mass extinction is commonly reserved for the five biggest events during which 75-96% of species were eliminated. These rare occurrences are of such magnitude that they stand out from the evolutionary turnover of species during normal geologic intervals. The problem with some of the smaller extinction events (i.e., other than the big five) is that due to an absence of precise, high-resolution fossil data, it is not clear whether they represent discrete, but smaller mass extinctions, or simply slight accelerations of normal background extinction over finite geological time periods (Sepkoski 1986). Overall, due to limitations with the fossil record, we don't really know how many mass extinctions have occurred. The fossil record will be discussed further in section 1.2.5, below.

1.2.3.2 Mass extinctions are not intensified background extinctions

Mass extinctions do not simply represent a "turning up the dial" of background rates (Jablonski 1986:129). That is, they are not just intensifications of normal evolutionary extinction patterns compressed into short (in a geological sense) timeframes. The end-Cretaceous mass extinction described above, for example, was not a mass extinction because all the non-avian dinosaurs died out rapidly and comprehensively, but because they were accompanied in death by a wide variety of marine protists, invertebrates, and other vertebrates as well from across the full spectrum of life.[1]

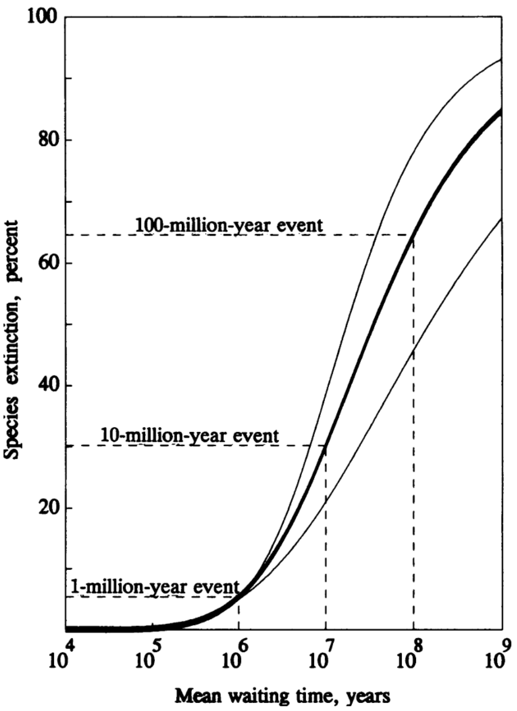
1 The evolutionary distinctiveness between mass extinctions and intensified periods of background extinction is one of the more complex aspects of extinction science requiring an engagement with Darwinian evolutionary theory. This will be expanded upon in chapter 2. For further details see Jablonski (1986, 2005) and Raup (1994).

1.2.3.3 Mass extinctions are nonselective

Species that might be considered extinction-resistant during background times, such as dinosaurs, found their adaptations useless at a time of mass extinction. They were at the top of the food chain, yet they still went extinct. Similarly, many species that appeared to be extinction-prone, such as small mammals, made it through the bottleneck unscathed (including our distant mammalian ancestors). The changeover in rules during mass extinctions not only means more species disappear but also that different kinds of species disappear (Myers 1990). Suffice to say, the regular rules of survival melt away with mass extinctions and both dominant incumbents and marginal players fall together in patterns that are unpredictable. Leakey and Lewin (1995:228) state, "Mass extinctions operate by different rules from those prevailing during background extinction. Darwinian evolution, important in background times, is suspended during biotic crises".

1.2.3.4 Mass extinctions are regularly spaced in geological time

Despite the common perception that mass extinctions are rare, almost freakish events, they have in fact been regular occurrences over the 541 million years of the Phanerozoic eon. Raup and Sepkoski (1984) have seemingly identified that mass extinctions are regularly spaced over geological time, exhibiting a 26 Myr periodicity. At the time, they suggested an extra-terrestrial forcing agent (orbital, gravitational changes) might produce such a phenomenon. After more than thirty years of research, to this day, no explanation has yet been found, but data covering most of the last half-billion years indicates that a 26 Myr periodicity exists (Melott 2017). Mass



Kill curve (dark line) for the past 600 Myr. The waiting time is the average interval between extinction events of a given extinction intensity. Thus, for example, a short episode of extinction which kills 30% of standing species diversity occurs on average every 10 Myr.

DIAGRAM 1.1 Periodicity and intensity of mass extinctions over the Phanerozoic eon
Source: Raup (1994)

extinctions of varying severity are seemingly a recurrent feature of Earth history and are predictable in both their regularity and intensity.

1.2.3.5 Causes of mass extinctions are fundamentally unknown

Little is known about the causes of mass extinctions, though instability in the carbon cycle seems to either proceed or follow them (Hannah 2015) and all appear to be associated with a major change in the Earth's biosphere (Barnosky 2012). Bambach states mass extinction events "are not homogeneous in intensity, selectivity, or timing, implying that they are not unified in cause" (Bambach 2006:142). Consensus on the full explanation for any mass extinction event has yet to be reached. Proximate causes such as volcanism, anoxic sediments, impactors, and sea-level change have received significant attention but how these interact with each other is not understood. Overall, there is a lack of data of the requisite resolution to understand much about mass extinctions on the scale of ecological time for which organisms live and die. Without adequate data, causes are mostly speculative.

1.2.3.6 Recovery from mass extinctions takes longer than the extinction event

A sense of accelerated death and destruction lurks in the concept of mass extinctions, but the end-Cretaceous event notwithstanding (which may have played out over as little as 1 year), they are usually drawn-out affairs lasting hundreds of thousands, even millions of years. The Ordovician event, for example, took as long as 3.3 Myr; the late-Devonian event maybe 29 Myr (Barnosky 2011). A striking characteristic of mass extinctions is that recovery normally takes longer than the actual event itself. That is the time before the taxon return to pre-extinction levels. Rebounds from mass extinctions are rapid in a geological sense, but from an ecological standpoint, they are slow. Biodiversity recovery, including the reestablishment of some communities, may take as long as 5-10 Myr (Raup 1994). The genus *Homo* has only been around for 2.8 Myr (Villmoare 2015) so we can see that biological recovery from a potential sixth extinction will be on a timescale that is meaningless to the human species.

1.2.4 What are the impacts of mass extinctions?

Mass extinctions generate such interest from evolutionary biologists and palaeontologists because of their profound ecological and evolutionary effects. Ecologically, the change in ecosystems across extinction boundaries may be as dramatic as the actual loss of taxa. Earth System succession may drive the ever-changing ecological stage on which species evolve, restructuring ecosystems and setting longer-term evolutionary trajectories (Hull 2015). From a macro-evolutionary perspective, they have two major aspects. First, through death, mass extinctions have profoundly influenced the history of life; second, the survivors have profoundly influenced the subsequent direction life takes. The interplay between these two destructive and generative aspects is very poorly understood (Jablonski 2001).

Mass extinctions can ultimately be seen as creative events, as they eventually lead to species formation exceeding the original diversity (diagram 1.2). They create opportunities for life to go into overdrive and the species rebounds that follow are a key component of macroevolution (Jablonski 1986). They free ecological space, which leads to speciation; they relax natural selections, allowing recoveries; and they open niches for adaptive radiations.[2] Mammals underwent two-thirds of their evolutionary changes in the presence of dinosaurs, but only after the dinosaurs had been eliminated could we reach the point we are now (Thomas 2018). In a 1985 discussion document, *Some Implications of Mass Extinction for the Evolution of Complex Life*, Sepkoski noted that mass extinctions may even be beneficial, "it may prove that total stability is actually detrimental to the evolution of complex life…since…perturbations of the biotic environment…may actually be essential to ensure the continuation of evolutionary experiments" (Sepkoski 1985:230).

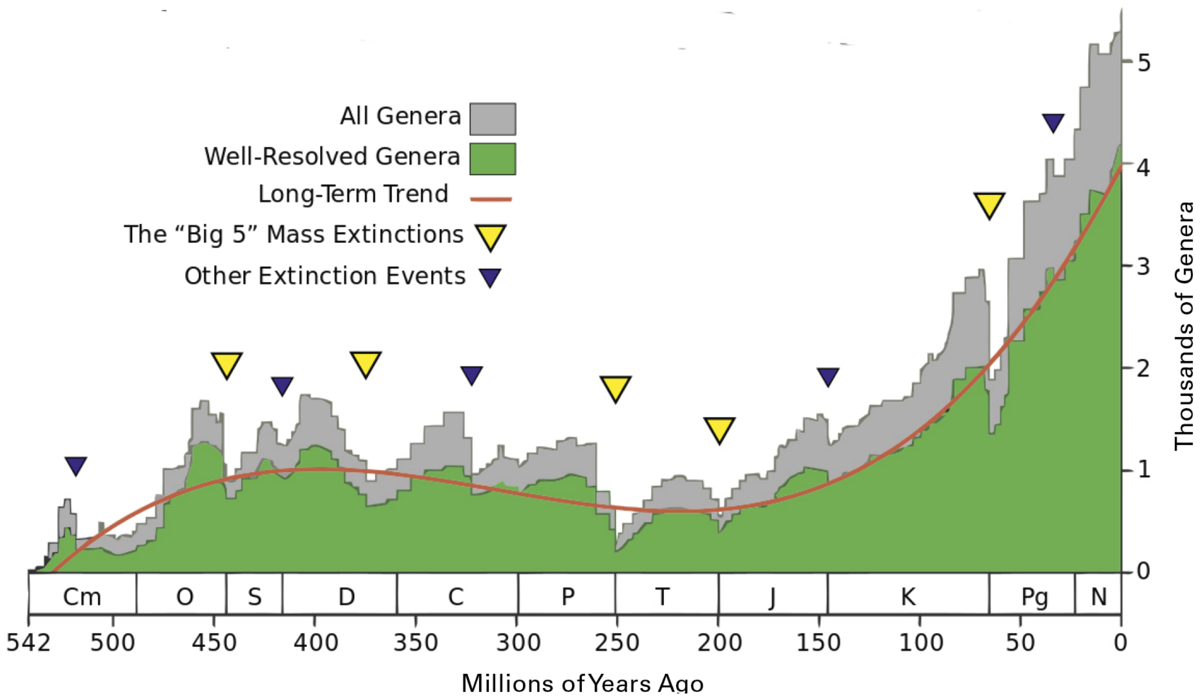


DIAGRAM 1.2 Biodiversity and extinctions during the Phanerozoic eon
Source: Wikipedia (2021)

The actual direction life takes following mass extinctions is impossible to predict. Survival may be temporary for many species, something Jablonski describes as "dead clade walking" (Jablonski 2001:5395). "Each extinction has examples of clades that survived the extinction event only to fall into a marginal role or eventually disappear" (Jablonski 2001:5395).

2 In evolutionary biology, adaptive radiation is a process in which organisms diversify rapidly from an ancestral species into a multitude of new forms, particularly when a change in the environment makes new resources available, alters biotic interactions, or opens new environmental niches (Schluter 2000).

Another intriguing characteristic is that for all their devastating impacts, mass extinctions have never reset the evolutionary clock[3] (Ho 2014). All the existing animal phyla (thirty-five[4]) first appeared during the Cambrian explosion of animals,[5] 541 Mya. As far as we are aware, no phylum has been lost since (Ward 2015), even after the end-Permian extinction event when 96% of species went extinct. Enough taxa and functional standing remained to seed recovery.

1.2.5 Identifying mass extinctions – the fossil record

Geological mass extinctions are identified through analysis of the fossil record, and they are a key element of all scientific debates and discussions. The absence or substantive drop of fossils within the strata over geological timescales (table 1.1) is a concrete indicator of a mass extinction. The known record contains about a quarter of a million different species, which are mostly extinct, and is dominated by the remains of multi-cellular organisms (Reznick 2011). It does not start with any continuity until 580 Mya, covering the pre-Cambrian period to the present, and is grouped into 35,000 genera and 4,000 families (see diagram 1.3, below for a summary of the taxonomic ranks of the biological classification system). It contains less than 1% of the estimated four billion species that have ever lived. Perhaps surprisingly, 90% of all identified extinctions have occurred outside of the five major extinction events (Raup 1991). The record is mostly made up of marine animals with hard skeletons that fossilise more easily (e.g., molluscs, brachiopods) and is biased in favour of successful species that survived for a long time and were geographically widespread. Short-lived local species such as birds and other soft-bodied animals probably have little chance of appearing in the record at all. As such, some consider species loss in prior mass extinctions may even be underestimated (Plotnick 2016). There are also significant sampling problems, particularly with the dinosaurs. Of the estimated 700 dinosaur species, half are known from just a single specimen. This makes it impossible to know when they first appeared and when they finally went extinct. Most of the specimens are also incomplete, comprising only part skeletons, which can make it difficult to be sure they are unique and separate species (Plotnick 2020).

Mass extinctions are usually identified through diversity compilations at the family or genus level with extrapolated species-level losses to minimise issues related to taxonomic standardisation and sampling. This differs from the approach used for current extinctions, which generally favour morphological or phylogenetic species approaches[6] (Hull 2015). The

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3 The evolutionary or molecular clock presents a means of estimating evolutionary rates and timescales using genetic data. These estimates can lead to important insights into evolutionary processes and mechanisms, as well as providing a framework for further biological analyses. Mass extinctions have never turned this clock backwards, undoing evolutionary progress over time.

4 For a complete list, refer to https://simple.wikipedia.org/wiki/List_of_animal_phyla

5 The Cambrian explosion of animals was an event 541 Mya that was a critical moment in the history of life on Earth, the time when most major groups of animals first appeared. It is referred to as an explosion owing to the relatively short timeframe over which it occurred, approximately 13-25 Myr.

6 Section 1.4, below, describes and discusses some of the different species concepts.

extent to which these approaches are compatible is subject to ongoing discussion (Trammer 2016), but many palaeontologists are sceptical of using the genus level analysis as a comparison point for the present (Sepkoski 2020). In other words, a standardised approach that enables deep time and present-day extinctions to be studied and compared by incorporating the use of ancient fossils is complex and may not even be possible. Overall, the low resolution of the fossil record makes mass extinctions very difficult to study rigorously. The magnitude and temporal details of both extinctions and species recoveries are almost certainly distorted by the general incompleteness and biases of the data. Most fossils prove nothing more than an organism's existence and death. And in few cases, particularly outside of mass extinction events, can we infer the reasons behind mortality.

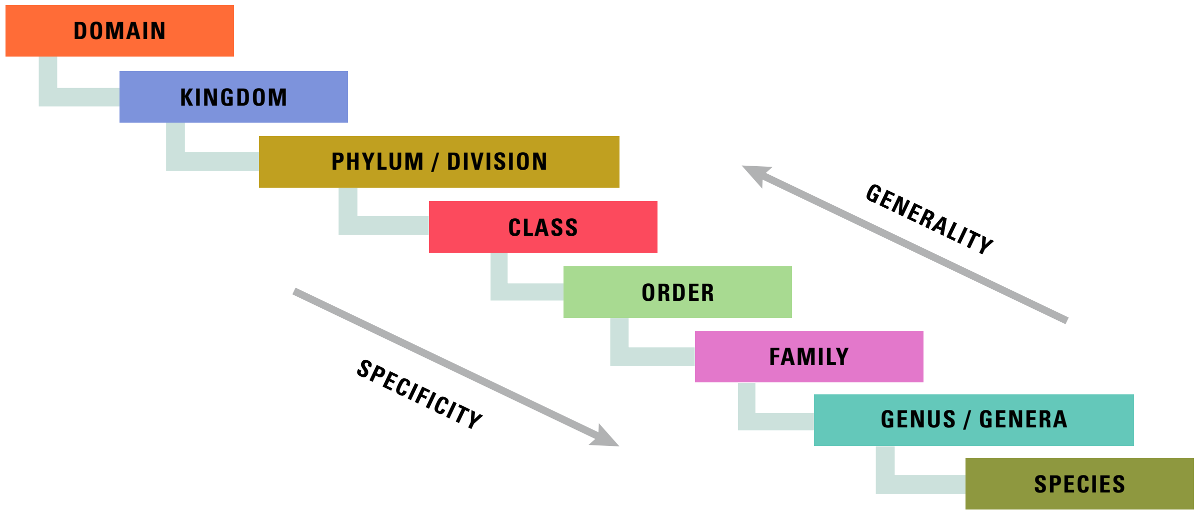

DIAGRAM 1.3 Taxonomic ranks in the biological classification system
Adapted from Saxena (2021)

1.2.6 The 'big five' mass extinctions

Of the total estimated species extinctions over the last half-billion years, only 4% coincided with one of the big five mass extinctions (Raup 1994). Yet these losses, and the conditions that accompanied them, had a fundamental impact on the entirety of life that followed, shaping the course of macroevolution. Their effects were so severe that they often mark the boundaries of geological time periods (table 1.1).

Conventionally, scientists normally designate mass extinctions as having 75% or more species extinct (Ward 2015). This number is purely a statistical artefact of choosing the five biggest events with the clearest geological signals, rather than a formally agreed baseline 'death level' that defines a mass extinction. Most popular attention is given to the end-Permian and end-Cretaceous extinction events which are the most distinctive. These are also by far the most researched. There is increasing evidence that the late-Devonian event may not have been a mass extinction at all, but rather a mass depletion of biodiversity driven by low speciation rates (Hull 2015). However, the popular power of the 'big five' ensures it remains in common usage.

Event	Ended Mya	Duration	Lost Genera	Lost Species	Proposed Causes	Losers	Winners
Ordovician	443	3.3 Myr -1.9 Myr	57%	86%	Onset of alternating glacial and interglacial episodes; repeated marine transgressions and regressions. Uplift and weathering of the Appalachians affecting atmospheric and ocean chemistry. Sequestration of CO_2	Strophomenid & rhynchonellid brachiopods, nautiloids, trilobites, crinoids, conodonts, graptolites	Siliceous sponges, tabulate corals
Late-Devonian	359	29 Myr -2 Myr	35%	75%	Global cooling (followed by global warming), possibly tied to the diversification of land plants, with associated weathering, paedogenesis, and the drawdown of global CO_2. Evidence for widespread deep-water anoxia and the spread of anoxic waters by transgressions. Timing and importance of bolide impacts still debated.	Stromatoporoids, tabulate corals, trilobites, cricoconarids, eurypterids, brachiopods, ammonoids, agnathans, placoderms	Chondrichthyans, actinopterygians (rayfinned fishes)
End-Permian	251	2.8 Myr -160 kyr	56%	96%	Siberian volcanism. Global warming. Spread of deep marine anoxic waters. Elevated H_2S and CO_2 concentrations in both marine and terrestrial realms. Ocean acidification. Evidence for a bolide impact still debated.	Brachiopods, crinoids, ammonoids trilobites, tabulate and rugose corals, basal tetrapods	Bivalves, gastropods, malacostracans, echinoids, scleractinian corals, archosaurs
Triassic-Jurassic	200	8.3 Myr -600 kyr	47%	80%	Activity in the Central Atlantic Magmatic Province (CAMP) thought to have elevated atmospheric CO_2 levels, which increased global temperatures and led to a calcification crisis in the world oceans.	Calcareous sponges, scleractinian corals, brachiopods, nautiloids, ammonites	Siliceous sponges, dinosaurs
End-Cretaceous	65.5	2.5 Myr -1 yr	40%	76%	A bolide impact in Yucatan is thought to have led to a global cataclysm causing rapid cooling. Preceding the impact, biota may have been declining owing to a variety of causes: Deccan volcanism contemporaneous with global warming; tectonic uplift altering biogeography and accelerating erosion, potentially contributing to ocean eutrophication and anoxic episodes. CO_2 spike just before extinction, drop during extinction.	Non-avian dinosaurs, ammonites, calcareous plankton, mosasaurs, pterosaurs, rudist bivalves	Birds, mammals, spiny-rayed fishes

TABLE 1.2 The 'big five' mass extinction events
Adapted from Barnosky (2011) and Hull (2015)

The five biggest mass extinctions are summarised below. Particular attention is drawn to the end-Permian event, 251 Mya, when about 96% of species are thought to have gone extinct (Barnosky 2011). This event is sometimes referred to as 'the great dying' (Brannen 2017).

1.2.7 Mass extinctions in Earth history: a summary

Even though just 4% of the estimated four billion species in the history of the planet were eliminated during mass extinction events over the past half-billion years, life in the Phanerozoic eon has been more affected by these events than all the other forces combined (Ward 2015). Any attempts to historicise life with a view to obtaining a relative understanding of anthropogenic environmental change in the present inevitably lead to an exploration of mass extinctions. This is on the basis they are some of the most significant, life-changing events in the history of the planet and human impacts are now equated to them. On the basis of the literature discussed above, we can summarise their key characteristics as follows:

- They are rare yet seem to be regularly spaced in geological time, occurring on average every 26 Myr
- Vary in intensity, but all involve a high number of species terminations
- Not simply intensifications of background extinctions – Darwinian evolution by natural selection is suspended during such times
- Non-selective and take place across diverse life forms – marginal players and successful incumbents can both disappear
- No single unifying cause and there is no agreement on the outright causes of any mass extinction, though climate change seems to be involved in all of them
- Can occur slowly over millions of years and do not require sudden or violent causes
- Recovery is longer than the actual extinction process
- Exert a major influence on macroevolution, profoundly shaping the subsequent direction of life
- All have led to post-extinction surges in species numbers
- May be necessary to build complex and resilient ecosystems
- Very difficult to study owing to the limitations in the fossil record, which is skewed towards marine invertebrates and long-lived species
- There have been as many as fifty mass extinctions, though popular attention is given to the largest five, which involved species loss of 75-96%

Whilst mass extinctions may be recurrent events over the past half-billion years of life on Earth, very little is known about them. Though they are identifiable within the geological record, major shortfalls in the fossil database are such that their proximate causes, durations, and recovery times are largely unknown. It is also speculated that their intensities may be underestimated owing to the failure of soft-bodied animals to fossilise. Notwithstanding this, mass extinctions are known to have exerted a major impact on macroevolution and for all the associated death and destruction, they are largely viewed as a constructive force by palaeontologists, driving species diversity and the evolution of complex ecosystems. For this reason alone, they may not be the best analogy for the environmental crises of the present. The issue of analogies will be considered further in section 1.5.

1.3 ANTHROPOGENIC EXTINCTIONS

The idea of a sixth extinction is driven by the perception that humans are causing biodiversity loss on a scale comparable to mass extinctions in the Earth's deep past. As described above, little is known about prior events which would seem to make it difficult to make such a grand pronouncement. Nevertheless, the proposition has gained significant traction, receiving widespread coverage across academic, journalistic, and public realms. This section will further explore the scientific basis of such a claim, focused specifically on near-time anthropogenic extinctions. It will begin with an overview of the sixth extinction idea and why it is so profound. I will then explore the pertinent extinction science, identifying three key variables utilised to gauge the intensity of contemporary biodiversity loss. This will show there is much uncertainty around each of them, centred around major data deficiencies. It will also identify the sheer amount of guesswork involved in estimates and projections of species loss, even within the most widely cited scientific publications. Overall, it will reveal that, as with prior mass extinctions, there is still much that is either indeterminate or totally unknown.

1.3.1 The sixth mass extinction concept

The idea that humanity is causing the sixth mass extinction has received so much attention over the past 30-years or so that it can now be considered a mainstream idea. Science journalist Elizabeth Kolbert's best-selling 2014 book, *The Sixth Extinction: An Unnatural History* received huge critical acclaim, including a Pulitzer Prize, and boosted what was already a popular idea still further. In a 2017 *Guardian* article about the 100 best non-fiction books of all time, it was ranked number 1, above notable scientific works by the likes of Darwin, Dawkins, and Hawking.[7] Similarly, the global environmental movement Extinction Rebellion's inaugural letter states, "we are in the middle of a sixth mass extinction" and sets biodiversity loss as the controlling agent of the movement (Extinction Rebellion 2019, as cited in Johnson 2020:40). It is clear the idea that humanity may have ushered in another mass extinction has received significant traction both publicly and scientifically.

Within anthropology, the idea has also been taken up. A Society for Cultural Anthropology Editors' Forum titled *Multispecies Care in the Sixth Extinction* adopts the term uncritically stating within the introduction that they take the sixth extinction "as a point of departure" (Münster 2021 et al.). In a 2013 article on human-related extinctions, anthropologist Todd

7 See https://www.theguardian.com/books/2017/dec/31/the-100-best-nonfiction-books-of-all-time-the-full-list

Braje states unequivocally, "Clearly we are currently living through a mass extinction event" (Braje 2013:13). Similarly, Richard Irvine states, "we are in the midst of a mass extinction event; indeed, we are a mass extinction event" (Irvine 2013:129). And Deborah Bird Rose, "… we are in the midst of the sixth great extinction event on Earth, the first to be caused by a single species, namely our own" (Rose 2011:Ch1)".

From the realm of the natural sciences, and perhaps surprisingly in view of the confident journalistic and anthropological assertions noted above, there appears to be no obvious agreement about whether we're in the sixth extinction or not. Ecologist Gerardo Ceballos, a pre-eminent voice in the extinction science community, states, "From the perspective of geological time, Earth's richest biota ever is already well into a sixth mass extinction episode" (Ceballos 2017:6089). Ecologist James Estes similarly states, "Our planet is presently in the early to middle stages of a sixth mass extinction" (Estes 2011:301). However, biologist and geologist Anthony Barnosky, author of one of the most widely cited papers on the sixth extinction has a different perspective, "the recent loss of species is dramatic and serious but does not yet qualify as a mass extinction in the palaeontological sense of the Big Five" (Barnosky 2011:56). Smithsonian palaeontologist Doug Irwin thinks the idea we're in a sixth extinction is nonsensical. He states, "People who claim we're in the sixth mass extinction don't understand enough about mass extinctions to understand the logical flaw in their argument…To a certain extent they're claiming it as a way of frightening people into action, when in fact, if it's actually true…then there's no point in conservation biology" (as quoted in Brannen 2018:Ch7). What Irwin is effectively saying is if we were already in the sixth extinction, there would be nothing we could do to prevent it – once biological and ecological tipping points are passed there is nothing that can reverse them.

So where did the proposition of a human-caused sixth mass extinction come from? And for the purposes of this chapter, is it empirically sound for scientists (both natural and social) to make or advocate for such a grand claim? Is the science settled, or close to being settled? If the notion of being in the sixth extinction is contingent upon a proper understanding of prior mass extinctions, then, as discussed above in section 1.2, they are mired in uncertainty so it would seem logically unstable to make such a declaration.

The sixth mass extinction term was first used by E.O. Wilson in 1992, "Humanity has initiated the sixth great extinction, rushing to eternity a large fraction of our fellow species in a single generation" (Wilson 1992:32). There is a long history of its emergence which, as I will explain in chapter 2, was a consequence of a whole sequence of events that can be traced back to the beginning of extinction research in the late 18th century, and which converged in the 1990s. At this point, there was little serious scientific evidence about anthropogenic extinctions to support such a claim. The proposition was more of a rhetorical device reflecting nascent concerns around biodiversity depletion (Sepkoski 2020). Rigorous scientific attempts to analyse contemporary species loss only really begin to kick off from the late 1990s, broadly coinciding with the proposition of the Anthropocene (Crutzen and Stoermer 2000). It is from this date most of my analysis below will concentrate.

The idea that humans may have initiated another mass extinction is a major scientific proposition. It suggests that humans are causing rupture on par with the natural forces of the past and have become geological agents. This places discussions about it within the broader Anthropocene narrative and helps explain how it has become one of the emblems of the global environmental crisis. Whilst humans from the onset have always been biological and ecological agents, it is only in recent times as we have reached numbers and invented technologies that are on a scale large enough to have an impact on the planet itself. A human-caused sixth extinction would itself likely be enough to designate humans as geological agents. Furthermore, if we are in or entering the sixth extinction, it would be the first time during the Phanerozoic eon – the only period in the long history of life for which there is a continual fossil record – that a mass extinction would have been caused by a single species. It would also be the first for which the primary trigger would be of clear biological origin, noting the big five all have strong abiotic signatures (table 1.2, above). The implications of a human-caused sixth extinction are clearly profound and of great scientific and ontological significance.

1.3.2 Contemporary species extinctions

For those outside the natural sciences, knowledge about species extinctions and the proposed sixth extinction is often assumed to be straightforward and, to a large extent, settled. But as we will see, this is incorrect. As (Heise 2016:Introduction) states, "Much about extinction science is extremely complex, indeterminate, or unknown". It relies on huge datasets that may be inaccessible to interpretation or critique by other scientists or non-specialists who may not have access to the data or techniques relied upon to produce them. Furthermore, by its very nature extinction research is a multi-disciplinary endeavour involving input from palaeontology, geology, biology, molecular genetics, ecology, physics, climatology, and chemistry, amongst others. It is a vast, highly complex, 'black-box' phenomenon entered at one's peril (Sepkoski 2020). From the vantage point of the humanities, it is perhaps unsurprising, therefore, that the particulars of extinction science receive little in the way of sharp scrutiny or analysis. Notwithstanding this, I will attempt to identify and examine some of the key issues and points of contention. In doing this, I hope to demonstrate that it is feasible for social scientists to scrutinise the scientific data and actively contribute to the scientific debates.

The primary variables required to understand the scale and extent of anthropogenic extinctions, relative to those over Earth history, are:

- The number of species on Earth
- The background rate of extinction (i.e., the normal rate of species extinction over geological timescales)
- The current rate of disappearance of species

It is the interplay of these three variables that are used to gauge the current extinction episode. This all sounds quite straightforward, but as we shall see, it is not.

Some of the key assumptions attached to obtaining and using these variables are:

- Species are an appropriate metric to evaluate human impacts upon the biological world. i.e., species loss can be equated to biodiversity loss
- Nature is knowable and can be measured, i.e., it can be quantified by humans in a meaningful way
- The past can be used as an analogue for the present

1.3.2.1 The number of species on Earth

Global species richness, estimated through either taxon, habitat, ecosystem, or the entire planet, is a key metric of biodiversity. It is a simple count of overall species numbers and does not reflect abundance within a particular area. Any attempt to understand the magnitude of the current extinction crisis necessitates an agreed estimate. If we do not know the number of species on Earth, then we cannot properly understand the scale of the current losses. It has been described as "one of the most fundamental numbers in science" (Larsen 2017:92).

Though only a fraction of the species that have ever lived are alive today, the absolute quantity is thought to be greater than ever before (Ceballos 2020; Ward 2015). And yet it is still not known, even as a rough estimate, how many. Caley (2014:187) identifies that after more than six decades of research, "estimates of global species richness have failed to converge, remain highly uncertain, and in many cases, are logically inconsistent".

The Catalogue of Life[8] currently contains 1.8 million described species (Roskov 2019). Owing to duplicates (i.e., the same species described more than once), it is thought that as many as 20% of these are undiscovered synonyms, reducing this to 1.5 million valid described species (Costello 2013). It is widely acknowledged that the number of described species is significantly less than the actual total number of global species. Projections of overall species numbers have generally ranged between 2 million (Costello 2012) and 100 million (Ehrlich and Wilson 1991). The most cited range seems to be 7-10 million, though this is mostly limited to eukaryotic (multi-cellular) species (Mora 2011). More recent estimates have endeavoured to include prokaryotic species (bacteria and archaea) and have placed the numbers at between 1-6 billion (Larsen 2017). There has even been an estimate as high as 1 trillion (Locey and Lennon 2016). The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services has recently stated there are 8.1 million animal and

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8 The Catalogue of Life is a collaboration bringing together the effort and contributions of taxonomists and informaticians from around the world. It aims to address the needs of researchers, policymakers, environmental managers and the wider public for a consistent and up-to-date listing of all the world's known species. See https://www.catalogueoflife.org/about/catalogueoflife

plants species but notes the number remains very uncertain (IPBES 2019). So why is there such a broad range of estimates?

Most calculations either totally exclude major branches of the tree of life (diagram 1.4, below), such as bacteria, or include numbers for such branches that are unrealistically low (e.g., Mora 2011). This despite bacteria being the most numerous life forms on Earth (Margulis 2000). A significant distinction between microorganisms and other branches concerns the definition of what constitutes a species, which will be discussed further in section 1.4. Bacterial strains with more than 70% DNA association are regarded as members of the same species. This is different from plants or animals, which are based on phenotypic features and the ability to interbreed. By way of comparison, applying the 70% DNA association to primates would designate them all as the same species (Staley 1997).

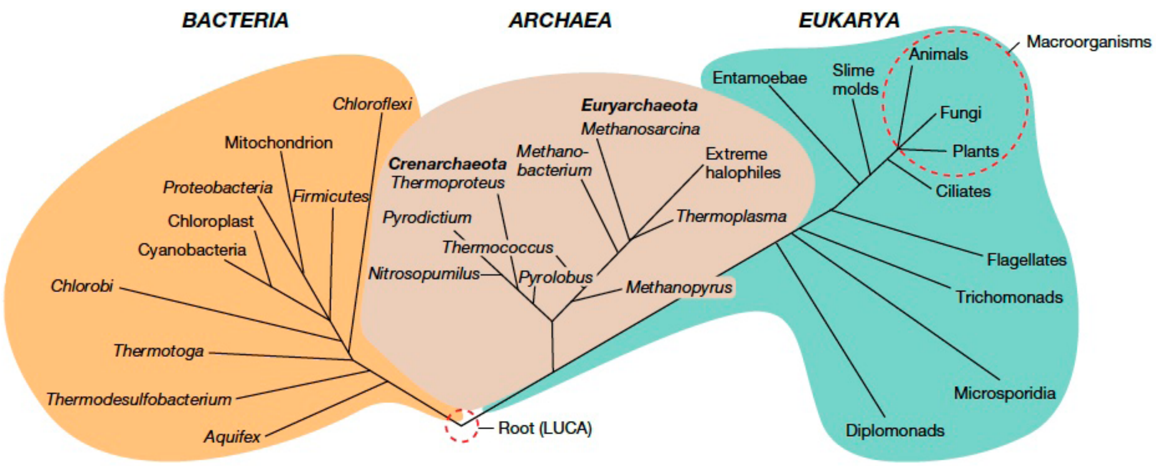


DIAGRAM 1.4 The universal phylogenetic tree of life
Source: Madigan (2019)
The universal phylogenetic tree of life as defined by comparative rRNA gene sequencing. The three domains of life – bacteria, archaea and eukarya are shown, along with the important representative groups. LUCA = the last universal common ancestor (3.5 to 3.8 billion years ago).

Most estimates also do not include morphologically cryptic species (i.e., species that look the same but are in fact different and cannot interbreed), discovered through molecular analysis, which would dramatically increase richness. Larsen (2017) suggests each morphologically based species may harbour as many as six cryptic species. Bellard (2012) has gone as far as suggesting that most biodiversity is cryptic via microorganisms and insects.

The traditional pie of life generally categorises animals and other eukaryotes to be the main branches. Regardless of absolute numbers, estimates are normally around 70-76% animals (of which 50% are insects), 15-20% plants, and 5-7% fungi (e.g., Wilson 1992; Mora 2011). The Catalogue of Life similarly reflects this: 98% of the described species on Earth are recorded within these three groups. Larsen's new pie of life (diagram 1.5, below) proposes a radically different breakdown of both the type and quantity. Whereas traditionally, prokaryotes are considered in the minority, occupying less than 0.5% of estimated species, he suggests bacteria may account for 78% of all species. Accordingly, he estimates there may be as many as 6 billion species overall, dominated by bacteria (Larsen 2017).

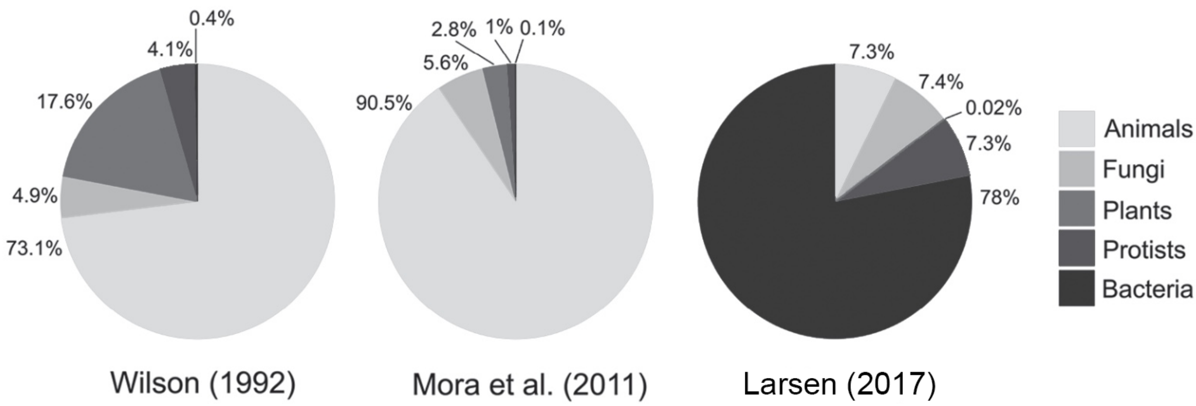


DIAGRAM 1.5 The new pie of life
Adapted from Larsen (2017)

To summarise, the main issues affecting the understanding of the number of species on Earth are as follows:

- Two of the three main branches of the tree of life, bacteria, and archaea are mostly ignored.
- This is in part explained by the different interpretations of what constitutes a species which affects both quantity and categorisation. For example, some microbiologists consider bacteria an “endless continuum of varieties”, rather than a “multiplicity of species” (Staley 1997:342).
- Only 1.5-1.8 million species have been described. Until this is dramatically increased, species numbers will mostly rely on estimates. Current taxonomic efforts describe, on average, 17,500 species per year (Costello 2013). If there are 8.1 million species on Earth, at the present rate, it will take until 2380 to describe them all.
- Estimating techniques lack sophistication and show few signs of standardising (Caley 2014).
- The morphological approach of taxonomy does not properly separate species. Using different approaches, for example DNA analysis, may identify cryptic or other distinct species.

These issues combined explain why the number of species on Earth is still fundamentally unknown. This makes any attempts to accurately measure the scale of the current crisis difficult. If mass extinctions are gauged at least in part by the overall percentage of species disappearing, without an accurate and agreed understanding of the total number of species on Earth, it is not possible to state we are in the sixth extinction.

1.3.2.2 The background rate of extinction

The background extinction rate derives from estimated lifespans of species in the fossil record during non-mass extinction events spanning the Phanerozoic eon. The purpose of it is to understand the rates at which species have gone extinct in the deep past. Theoretically, this can then be compared to current extinction rates to identify whether they are occurring at an elevated level.

Mean lifespans of species in the fossil record vary by taxonomic group and range between 1–10 Myr (Lamkin 2016). From the 1990s until about 2014, the lower value of 1 Myr was commonly used to determine background extinction rates against which mass and contemporary extinctions were gauged. The shorter lifespan was used as it translated into a higher rate of background extinctions than a longer lifespan would. This conservative approach reflected uncertainties in the fossil record, including quantity/quality and the state of species-level taxonomy. Acceptance of the longer lifespan (10 Myr) would imply a lower background extinction rate as species endure longer.

Inferring background extinction from a taxonomic longevity of 1 Myr adopts the simple logic that in a pool composed of one species, there would be one extinction every one million years. If this was scaled up to a pool comprised of a million species, it would amount to one species extinction per year. Either scale would be numerically expressed as 1 E/MSY (extinction per million species-years) and until recently, this background extinction benchmark was generally accepted (Lamkin 2016).

Barnosky queried the 1 E/MSY figure on the basis extinction rates can vary markedly, dependent upon the duration they are measured over. He stated, "Extrapolating a rate computed over a short time…will probably yield a rate that is either much faster or much slower than the average million-year rate" (Barnosky 2011:53). He also claimed recent data proved average species durations varied significantly by genus and that using one single background extinction rate may be inappropriate. De Vos (2014) also challenged the benchmark, believing the 1 E/ESY was far too high. He presented results from molecular phylogeny models purportedly demonstrating lower rates of background extinction and diversification within five major taxonomic groups. This confirmed the longer average species duration (10 Myr) rather than the shorter (1 Myr) would be the more appropriate benchmark to calculate background extinctions. This equated to a background extinction rate of 0.1 E/MSY, one-tenth the earlier rate. To be clear, he was proposing that the background extinction rate would ordinarily be 1 species extinct every 10 million years instead of 1 species extinct every 1 million years, a significant re-estimation. There is still no agreement about which background rate is the most accurate and both often are incorporated when describing near-time anthropogenic extinctions. For example, "a third of all species are at risk of extinction, and they are going extinct 1000 to 10,000 times the background rate" (Pimm 2015:170). This range is reflective of the above discussions.

An understanding of the background extinction rate is important for three reasons. Firstly, it is a baseline against which the occurrences of historical mass extinctions are nominally identified; secondly, it helps us to gauge the severity of them; and thirdly, it is used as a reference point to understand current extinctions. To be clear, there is a 1000% difference between the commonly used lower and upper background extinction rate (i.e., from 0.1 E/MSY to 1 E/MSY). This has clear ramifications in gauging the intensity of species disappearances in both the past and, more significantly, the present. Against what background rate are the present-day extinction rates compared to? Without an agreed understanding of the background extinction rate, any attempts to gauge the scale of the current extinction episode relative to those in the past will be speculative, with the potential for a wide range between upper and lower estimates.

1.3.2.3 The current rate of disappearance of species

It is difficult to find many researchers who does not agree that globally, species extinctions are increasing over time due to human actions. There is, however, significant uncertainty about the scale of these losses, both historically and in the present. Stork, for example, states, “there are almost no empirical data to support estimates of current extinctions of 100 or even one species a day” (Stork 2009:365). This contrast markedly with Dirzo (2014) who states we are losing as many as 58,000 species annually. Future projections also vary in their intensity. Wilson (2002) believes half the Earth’s species may be gone by 2100, whereas the IPBES (2019) think a million species are at risk of extinction by 2050.

The first historically known extinctions due to humans are thought to have occurred between 10-50 kya during the late Quaternary period when human geographic expansion and population growth worldwide, driven by large game hunting, contributed to two-thirds of all mammalian megafauna (animals above 44kg) becoming extinct everywhere except Africa (Martin 2007).[9] This event was an extinction spike that exceeds all but one episode over the past 55 Myr and the loss of phylogenetic diversity has no analogue within the fossil record (Davis 2018). Although it was a mass extinction of mammalian megafauna, it is not considered a mass extinction overall because it only affected one clade – synapsids[10] (Hull 2015). Closer to the present, whilst there have potentially been significant historical extinctions over the entirety of the Holocene, there is little fossil evidence. Estimates suggest there were thousands of avian extinctions in Hawaii, Polynesia, the Marianas, and New Caledonia following colonisation by humans over the past 2,000 years but there is little empirical evidence beyond isolated bone fragments (Stork 2009). Written records of the disappearance

9 There has been considerable discussion about whether these extinctions were driven by humans or climate change. The extinctions coincided with the Younger Dryas Climatic Episode that resulted in temperature variations of up to 10 degrees Celsius in a decade (Barnosky 2010). After more than fifty years of debate, the majority consensus seems to be that the arrival of modern humans was the main driving factor in the late Quaternary extinctions in most land areas outside of Africa (Sandom 2014; Bartlett 2016; Svenning 2017), though climate change is still considered contributory (Hocknull 2020).

10 Synapsids are a group that includes mammals and every animal more closely related to mammals than to the other members of the amniote clade, such as reptiles and birds.

of mammals, birds, and reptiles first date back to the 16th century with the beginning of European expansionism.[11] It is from this time that anthropogenic extinctions are formally tracked by international bodies, most notably the International Union for the Conservation of Nature (IUCN) and their Red List of threatened species which will be discussed below.

IMAGE 1.2 Prehistoric men battle cave bear
Illustrator: Figuier, Louis (1870), sourced from the British Library
Prehistoric men using wooden clubs and stone axe to fend off an attack by a large cave bear. The cave bear (*Ursus spelaeus*) was a species of bear that lived in Europe during the Pleistocene and became extinct at the beginning of the Last Glacial Maximum, about 24,000 years ago (Pérez-Ramos 2020).

The IUCN Red List of threatened species

The IUCN Red List of Threatened Species is an ongoing inventory of the global conservation status of plant and animal species. The IUCN (2020) describes the Red List as "a critical indicator of the health of the world's biodiversity". It has no legal force, yet it has become the standard reference work for conservation, both in raising awareness and helping to direct conservation focus. The list is now embedded in global policy initiatives such as the IPBES and the United Nations Sustainable Development Goals. Using a set of quantitative criteria, it evaluates the threat status of all the species it has assessed. It tallies the list of recorded extinctions since the 1500s and lists the species currently threatened with global extinction.[12]

11 As will be discussed in chapter 2, there was no concept of extinction at this point.

12 For a detailed explanation of the functioning of the IUCN Red List, see Mace, Georgina M., et al. 2008. "Quantification of Extinction Risk: IUCN's System for Classifying Threatened Species." *Conservation Biology* 22 (6): 1424–42.

Species	Cat. Life Described	IUCN Assessed	% Assessed	IUCN Threatened	IUCN Extinct	% Extinct
Eukaryotes						
Animalia	1,296,192	78,126	6.03%	15,166	779	0.06%
Chromista	23,487	0	0.00%	0	0	0.00%
Fungi	135,110	353	0.26%	185	0	0.00%
Plantae	366,474	50,369	13.74%	20,360	123	0.03%
Protozoa	2,720	70	2.57%	54	0	0.00%
Prokaryotes						
Archaea	377	0	0.00%	0	0	0.00%
Bacteria	9,980	0	0.00%	0	0	0.00%
Viruses	3,187	0	0.00%	0	0	0.00%
Total	**1,834,340**	**128,918**	**7.03%**	**35,765**	**902**	**0.05%**

TABLE 1.3 Described, assessed, threatened, and extinct species
Adapted from Roskov (2019) and IUCN (2019)

As can be seen from table 1.3 the IUCN believes 902 species have become globally extinct since 1500. This equates to approximately two species per year. As a percentage of the Catalogue of Life's total described species of 1.83 million, this represents an extinction rate of 0.05% over the past 520 years.

A surprising aspect of the Red List data is that just 7% of the total described species from the Catalogue of Life have been assessed for extinction risk. Noting that the number of described species is probably much lower than the actual number of species on Earth, 128,818 seems like a very small number. As was described above, the IPBES (2019) recently estimated there are 8.1 million species on Earth but that there are significantly higher estimates placing the number of species into the billions (e.g., Larsen 2017). The fact is, only a small fraction of the species on Earth have been assessed for any kind of extinction risk, probably less than 1%.

Significant Red List attention is given to vertebrate species, with approximately 75% of all described species assessed for extinction risk. Contrast this with insects, by far the most numerous animals on Earth (Wagner 2020), with just 1% of all described species assessed to date. Also, the IUCN has not risk-assessed *any* prokaryotic species (archaea and bacteria –diagram 1.4), believed to be the most numerous organisms on Earth.

It seems obvious from even a cursory analysis of the Red List that there are serious information deficiencies that may call into question its claim as "a critical indicator of the health of the world's biodiversity" (IUCN 2019). Can such a limited dataset be used to gauge contemporary extinction rates? Can these rates reasonably be compared to background levels to determine the overall magnitude of the current extinction episode? Not only have few species (7%) been assessed from the overall Catalogue of Life, but as an assessment of the total number of species on the planet (potentially billions) it falls dramatically short. The Red List also shows clear biological prejudices, with the majority attention given to plants and animals, with none whatsoever given to microbial life. Functionally extinct species[13] are also ignored despite the IPBES (2019) recently estimating half a billion species may already be consigned to extinction due to habitat change alone.

The true extinction magnitude is not apparent from the IUCN Red List, despite its prominence within conservation. The number of currently documented extinctions is likely to be a serious underestimate, a point widely recognised in scientific circles (e.g., Cafaro 2015; Barnosky 2011). Dirzo (2014), for example, estimates that as many as 58,000 extinctions may be occurring annually. Contrast this with the Red List which records 902 species extinctions *since* 1500. It is almost certain that many species have probably gone extinct prior to being even discovered and catalogued (Costello 2013). So, if the Red List does not provide a realistic measure of the number of contemporary anthropogenic extinctions, what other data sources are available?

Modelling extinction

In the absence of empirical observations of actual extinctions, magnitude estimates that rely on theoretical predictions are therefore utilised. There are a wide variety of approaches that produce a broad range of outputs. Perieria (2010) conducted a review of projected extinction models that produced a hundred-fold range of extinction rates. The range was contingent upon the different drivers considered (e.g., climate change, land-use change), model approaches, taxonomic coverage, and geographic scale. The ongoing challenge for researchers is to evaluate these projections against documented extinctions to identify the most accurate method. This is very difficult owing to a shortage of information.

Two of the most common modelling methods are the ‘species-area relationship’ that derives species loss from habitat change and known or estimated species numbers, and models using Red List data allied with fossil record information that endeavours to understand current extinction rates relative to those across geological timescales.

Extinction models using the species-area relationship

Kolbert, in *The Sixth Extinction* states, “For the purpose of thinking about extinction the species-area relationship is key” (Kolbert 2014:Ch8). Until 20 years ago, this modelling approach was a common method for estimating both species richness and loss and many of the direst extinction projections are based around this technique. In its simplest formulation, the species-area relationship tells you the bigger the geographical area you sample, the greater the number of species you will encounter. Conversely, it also purports to tell you that if a particular area is subject to habitat loss or change, there will be a consequential impact on species numbers.

13 Functional extinction is when a species is reduced in abundance, short of outright extirpation, to the point where it no longer interacts significantly with other species in the community (Broadie 2014).

One of the early formulations of the species-area relationship was the claim by Wilson (1992) that 27,000 species a year were disappearing due to rainforest loss. At the time, Wilson emphasised the figure was "cautious" and "selected in a biased manner to draw a maximally optimistic conclusion" (Wilson 1992:Ch12). His estimate was based upon a species-area extrapolation of the number of arthropod[14] species found in a single hectare of Panamanian rainforest by ecologist Terry Erwin who estimated there were 30 million species worldwide (Erwin 1982). Wilson used this number and applied it to global forest loss to arrive at 27,000. Both Wilson and Irwin's estimates remained in circulation for decades but are now recognised by scientists as being incorrect. Neither matched subsequent investigation – something Kolbert (2014:Ch8) believes "should be chastening to science writers perhaps even more to scientists".

A more recent iteration of the species-area relationship was Thomas' (2004) study of the extinction threat caused by climate change. He estimated 15-37% of global species would be committed to extinction by 2050 under minimal IPCC climate change predictions. As with Wilson's estimate, it received significant popular attention, including a front cover in *Nature*. The BBC also published an online feature about it with the headline, "Climate change could drive a million of the world's species to extinction".[15] The article was challenged on several grounds, including the underestimation of the adaptive capacities of plants and animals to persist in changed environments or that they could migrate to more favourable locations (Kolbert 2014). Thomas (2013) has subsequently radically changed his position, speculating that the Anthropocene will probably result in higher overall biodiversity in the long term, including climate-driven speciation. This will be discussed further in chapter 4.

Certain authors have argues that species-area relationship models over-estimate extinction (Fangliang 2011) and are not an accurate way to produce estimates. They normally use data from local or regional areas extrapolated across the entire planet, introducing a wide margin for error. They also underestimate the capacity for species to persist, adapt, or migrate to new locations. Nonetheless, estimates using the species-area model have attained extensive publicity and continue to exert a strong influence.

Extinction models using Red List data

More recent extinction estimates use allied models combining empirical data from the Red List, the fossil record, and knowledge of prior mass extinctions. They still involve the extrapolation of relatively minor data sets over space and time to make significant declarations about the state of the planet's biodiversity. In one of the most commonly cited papers on the sixth extinction, Ceballos (2015) assesses modern rates of vertebrate species extinctions.

14 Arthropod, (phylum Arthropoda) are the largest phylum in the animal kingdom. It includes familiar forms such as lobsters, crabs, spiders, mites, insects, centipedes, and millipedes. Around two-thirds of all known species of animals are members of this phylum (Odegaard 2000).

15 http://news.bbc.co.uk/2/hi/science/nature/3375447.stm

He does this by utilising empirical Red List data for vertebrates, comparing them with "a recent background rate for mammals" (Ceballos 2015:1). He is unable to use an actual background rate for vertebrates as a whole due to limitations in the fossil record, so instead uses the rate for mammals over the past few million years and "assumes the rates for other vertebrates to be similar to other mammals" (Ceballos 2015:2). The modern rate used for vertebrate extinctions is derived from the Red List, specifically since 1900, on the basis that most recorded extinctions have occurred in the last 114 years. His results conclude, "modern extinction rates for vertebrates vary from 8 to 100 times higher than the background rate" and, "…a mass extinction is underway" (Ceballos 2015:3). The question must be asked: can a speculative background extinction rate for mammals really be used as a baseline to gauge present-day extinction intensities for the likes of birds, reptiles, amphibians, and fish? And more to the point, if the Red List has evaluated the extinction status of only a small percentage of all known animals, to what extent can an analysis of forty thousand[16] vertebrate species be relied upon to make a determination that a mass extinction covering all forms of life is underway? Briggs (2016) has suggested the results constitute bad data and there are ethical problems with their publication.

Another oft-cited paper by Barnosky (2011) uses Red List data for 'some' vertebrates (birds, mammals, amphibians, reptiles) either recorded extinct since 1500 or threatened with imminent extinction in the near present. The intensity of these actual/projected extinctions is then compared with theoretical extinction intensities across all categories of life during the big five mass extinctions. He identifies the extinction intensities in the present for birds, mammals, amphibians, and reptiles are higher than overall extinction intensities during the big five. This leads him to conclude, "current extinction rates are higher than those that caused Big Five extinctions in geological time; they could be severe enough to carry extinction magnitudes to the Big Five benchmark in as little as three centuries" (Barnosky 2011:55). For the avoidance of doubt, extinction intensities in the present for certain categories of life are used and then extrapolated across all forms. Furthermore, broad assumptions are made about the big five extinction intensities that are themselves surrounded by uncertainty, as described in section 1.2.2. So little is known about mass extinctions, including the durations they occurred over, that any intensity estimates could only ever be loose approximations. For example, the end-Triassic mass extinction is thought to have occurred over 600 kya-8.3 Mya, which would provide very different intensity estimates dependent upon the precise extinction duration utilised. Furthermore, as described, the fossil record is fundamentally composed of marine invertebrates such as molluscs, making any generalised background rate inherently unrepresentative if compared with specific categories of life in the present (in this instance, vertebrates).

16 The number of assessed vertebrate species within the 2014 edition of the Red List Summary Data, current at the time of Ceballos' 2015 paper.

The Ceballos and Barnosky papers are interesting case studies that highlight the difficulties and sheer amount of guesswork when estimating present-day extinction rates. They both rely on Red List data that is mostly incomplete, with just 129k species presently assessed for extinction status (table 1.3). They both use vertebrates for their analysis and extrapolate the results across all categories of life to determine if we are in or nearing the sixth extinction. They both rely on a fossil record that is limited in quantity and diversity (recall of the estimated four billion species in the history of the planet, the fossil database comprises just 250k species of mostly marine invertebrates). Yet, they are both two of the most cited scientific papers in discussions around the sixth extinction.

To summarise, it is currently unknown, to an order of magnitude, the current rate of disappearance of species due to human activities. The IUCN Red List (2019), which describes itself as a critical indicator of the health of the world's biodiversity, declares that just 902 species have gone extinct since 1500 (table 1.3). This differs markedly with eminent extinction scientists, such as Dirzo (2014), who believes we may be losing as many as 58,000 species annually. Yet, as Stork (2009) points out, there is little empirical evidence of even one species extinction per day. In response to the absence of concrete information, scientists have turned to modelling techniques to produce magnitude estimates. As described, this results in a wide range of calculations, many of which are difficult to evaluate owing to the significant amounts of guesswork and extrapolation involved. Some of these estimates appear to be crudely put together, such as the Wilson (1992) calculation described above. Yet they have attained significant traction within both the scientific and popular realms, taking on a life of their own. They receive little in the way of detailed scrutiny, not least by environmentally focused social scientists, and there is a sense that the absence of reliable information used to put the estimates together is underplayed. It is hard to see how they can be relied upon as a measure of anthropogenic species loss.

1.4 THE BIODIVERSITY AND SPECIES CONCEPTS

As will be apparent from the chapter so far, the concepts of biodiversity and species dominate the discourse on extinction. They are the units through which biological life is often defined, evaluated, and managed and they need to be properly understood, including knowledge of their inherent definitional limitations, if a reflexive understanding of extinction science is to be attained. Certain authors (e.g., Mitchell 2016) think the species concept is too often 'securitised' and deemed so important that it cannot be discussed, lest it undermine conservation efforts. This can lead to uncritical use of the species and biodiversity terms when discussing extinction risk, contributing to the overall crisis by entrenching dominant perspectives that fail to confront many of the scientific tensions and uncertainties. It is worth briefly digging into these concepts as they illustrate there is yet another layer of complexity to the discussions so far.

Biodiversity is a higher-order concept that includes almost everything to do with life on Earth (Thomas 2013). Owing to its scope and multidimensionality, there is no accepted definition, and, in fact, the widest consensus seems to be that it cannot be quantified through any one single operational measure (Morar 2015). This problem has been met in practice through the utilisation of proxies, the most common of which is species richness. Whilst some consider species richness as only the tip of the underlying iceberg of biodiversity (Mishler 1999) most impact analysis on the loss of biodiversity base their data on species extinctions. This includes the IUCN and WWF through the Red List and the Living Planet Index (WWF 2020).[17]

Species function as the currency of biology and are as fundamental as elements are to chemistry and particles to physics (Costello 2013). Yet over 300 years since the term was first used,[18] there is still no commonly accepted definition and there are over twenty competing concepts (Mitchell 2016). Dawkins suggests species are like arbitrary stretches of a continuously flowing river and, like passing clouds, are always taking new shapes. He considers them but temporary vehicles for the onward transmission of the genome through time with their actual form of secondary importance (Dawkins 1976). Kohl (2017:S27) suggests species “defend a particular form of life pursuing a pathway through the world, resisting death (extinction), by regeneration and maintaining a normative identity of over time”. Rolston III (1985:721) believes, “a species is a coherent, ongoing form of life expressed in organisms, encoded in gene flow, and shaped by the environment”. Darwin meanwhile thought of the term as “arbitrarily given for the sake of convenience to a set of individuals closely resembling each other” (Darwin 1859:Ch2). One thing all concepts of the term have in common is seeing species as lineages. They vary on how the lineage is cut.

The biological species concept is the current dominant model within most branches of biology. The most quoted definition is by zoologist Ernst Mayr from 1942, “groups of actually or potentially interbreeding natural populations which are reproductively isolated from other such groups” (Mayr 1942, as cited in Kirksey 2015:761). Straight away, we can identify a weakness: many life forms reproduce asexually, including plants and, more obviously, bacteria and archaea (two of the main domains of life). This may help explain the absence of bacteria and archaea from the IUCN Red List. Mitchell (2016) criticises the heteronormativity of the biological species concept, as she believes it propagates dominant social, economic, and political systems. This view prompts us to reflect that the terms species and biodiversity are not neutral and are far from purely scientific endeavours.

For taxonomy and species identification purposes, the morphological species concept is commonly utilised. This identifies species by their physical characteristics and can be applied to both sexual and asexual organisms. It can also be used when analysing the fossil record. One of the obvious limitations with the morphological species concept is that sometimes species are sympatric (i.e., morphologically indistinguishable) but are clearly from

17 The Living Planet Index is a periodic measure of the state of the world's biological diversity based on population trends of vertebrate species from terrestrial, freshwater, and marine habitats. The latest iteration was released in 2020. See https://livingplanet.panda.org/en-gb/

18 The first recorded use of the term was by Dutch polymath, Christiaan Huygens, in his 1698 book, *Cosmotheoros,* which was a speculation on the habitability of other planets.

different lineages (Aldhebiani 2017). As discussed in section 1.3.2.1, this leads some to think there may be many species erroneously classified under single names, which could significantly underestimate global species richness.

The phylogenetic species concept (PSC) views species as complexes whose members are descended from a common ancestor and whom all possess a combination of certain defining traits. Hence, this version of the concept defines species as a group having a shared and unique evolutionary history. The problem with the PSC is that slight differences can be found within virtually any group of organisms which can encourage an extreme division of species into ever smaller groups. Sometimes variation can be larger within than between species (Persson 2008). One argument for the use of PSC is that it can help identify species evolutionary distinctiveness. Dominant within discussions of extinction is the notion that all species are created equal. However, some species are more isolated within the phylogenetic tree, which gives them a particular rarity value. The loss of certain animals (e.g., rhinoceros) can cause the loss of far more distinctive evolutionary history than, say, the loss of certain species of birds that may be genetically very similar to other bird species. Combining a species current imperilment with its evolutionary distinctiveness can therefore help direct conservation policy and could lead to markedly different conservation priorities (Davis 2018).

Central to all the species concepts above (which are three amongst over twenty) is the notion of individuality. This is the idea of species 'standing alone' as islands independent of other species. Through a process of intra-species reproduction, they evolve into new species or, because of maladaptation, they reach the end of the evolutionary line and become extinct. Recent developments in molecular phylogenetics, however, have shown this to be wrong. The neo-Darwinian view of evolution (the 20th century school of thought merging Darwin's theory with genetics) believed that the primary source of evolutionary innovation came from genomes flowing vertically through time, exchanged by and amongst host species. But through a process known as Horizontal Gene Transfer, it is now understood that genes also flow laterally between taxa. This is often referred to as the endosymbiotic theory of evolution, as advanced by Lynn Margulis in the 1960s. Endosymbiosis states that rather than species being unambiguously individual, all are, in fact, composites brought into being through the genes of strangers. This happens primarily through the lateral flow of bacteria. Humans provide a good example of this. Each person contains five million bacterial genes to its genome, ten times more than the human host genome (Quammen 2018). In other words, the main evolutionary novelty in species comes from the acquisition of genomes from others, rather than the same kind. This has been described as "the real origin of species" (Quammen 2018:Ch36).

It is clear that whatever species are, whatever they are made of, and how we define and categorise them is highly technical and much debated. However, these debates are far from academic. They mark differences in how the world is perceived, the nature of nature, and, to a certain extent, the nature of reality. Anthropologist Eben Kirksey questions whether species can even be said to exist outside the human imagination. He asks, "Is a species a natural kind that exists independently of its discovery, or naming by humans?" (Kirksey 2015:758).

Tim Ingold (2013) has advocated the abandonment of the species concept on the basis it is purely an anthropocentric idea. "Only in the purview of a universal humanity", he maintains, "does the world of living things appear as a catalogue of biodiversity, as a plurality of species". He argues, "If we abandon this sovereign perspective, then the very notion that creatures can be grouped on the basis of similarity and divided on the basis of difference, and with it the concept of species itself, will need to be rethought" (Ingold 2013:19). What he is alluding to is the need to see beyond the singular (i.e., individual species) towards webs and networks that facilitate life for individual beings and as an ongoing planetary phenomenon. Viveiros de Castro (2013) similarly queries if the category of species is still useful for understanding the world, prompted through his work with indigenous Amazonians, where the notion of species is markedly different. Despite this, Kirksey (2015) has argued that even though there are many uncertainties, species are a valuable sense-making tool and abandoning the idea of them would mean losing a useful means of grappling with other animate beings. Royston III (1985) similarly warns that unless we acknowledge species exist beyond the mind of humans, it is hard to say humans have any duty to save them.

The species and biodiversity concepts are highly politicised and not just a matter of science, but also (and perhaps mainly) one of culture (Heise 2016). Tracing the roots of the terms reveals deeply value-laden concepts that subsume multiple values – aesthetic, recreational, scientific, economic, and life-support (Uggla 2010). How we interpret them guides decisions about how much and what type of nature is to be conserved. If we understand biodiversity as intermingling ecological processes rather than just as an aggregation of objects (species), then to conserve it, we create a space in which those processes can unfold (Kohl 2017). But the uncritical use of single indicators, such as species, to measure life and changes to that life seems reductive and unsatisfactory. Particularly as McFall-Ngai (2017:M57) reminds us, "ideas of how the biological world is put together remain very much in flux".

1.5 DISCUSSION

Science historian Naomi Oreskes, in her recent book, *Why Trust Science?* declares, "science is the practice of forming meaningful statements and using observations to judge whether the meaningful statement is correct or not" (Oreskes 2019:Ch1). In other words, if a statement can be verified through observation, then we're justified in accepting it as true and constitutive of scientific knowledge. Munro (2019:798) defines science denialism as "the rejection of the well-supported facts and concepts that underpin a scientific consensus". With these two definitions in mind, and based on the chapter so far, what are we to make of extinction science overall? If much of it is intermediate, not based upon observations (extinction has rarely, if ever, been seen), and not agreed upon, how can it be established as trustworthy? And if the trustworthiness of much of this science cannot be established at what point does rejection of it, either explicitly or through the production of markedly different counter-ideas, constitute denialism?

These kinds of ruminations matter because, as discussed throughout, not only are few aspects of extinction science agreed upon, but the range of opinions is often extreme. An illustrative example of this relates to estimates about the number of species on Earth, a key metric to help gauge the scale of the current extinction episode. As discussed in section 1.3.2.1, amounts range from three million to a trillion and over the past sixty years, they show no sign of converging. Margulis (2000) reminds us that science is asymptotic – it never arrives at final knowledge. But with global species numbers, it seems reasonable to query how much knowledge has been determined at all.

The impression I have from my review of some of the major extinction science articles and publications is that many occupy a kind of scientific 'no-man's-land'. They purport to reveal something significant, but close inspection reveals major knowledge gaps, assumptions, and extrapolations that render their findings largely inconclusive. We can see a concrete example of this with the recent IPBES (2019) estimate of the number of insects threatened with extinction. The number of insect species on Earth is unknown, though was recently estimated to be 5.5 million (Stork 2018). The quantity of actually described insect species in the Catalogue of Life is currently 1.1 million. Of the 1.1 million, only ten thousand (1%) have been IUCN Red List assessed for their extinction threat status. Evidence from dragonfly studies and European studies of bees, butterflies, and beetles (most of the data) suggests 10% may be at risk of extinction (IPBES 2019). The IPBES takes this 10% value (which to be clear is derived from a threat assessment of less than 10k different insect species) and applies it to Stork's estimate of insect species (5.5 million) to arrive at a figure of 550,000 species at risk of extinction, which is then rounded down to half a million for ease of communication. The obvious question to ask is whether this meets Oreskes' criteria of consensual science? Probably not, yet it is included within a major international report that made headlines around the world because of the claim that one million species (including half a million insects) are at risk of extinction within the coming decades. Furthermore, does rejection of these numbers, put together by a major international body (the IPBES we could say are the biodiversity equivalent of the IPCC) constitute denialism? As Sagoff (2018) reminds us, distinguishing denialism from critique is not always straightforward when undertaken across disciplines. However, thinking these numbers may be unreliable seems more akin to rudimentary analysis than the denial of scientific fact.

One of the key statistical approaches for assessing the intensity of the current extinction episode is the use of analogues. Analogy is at the heart of methods for extrapolating about past phenomena by making analogies with phenomena observable today. But what degree of sameness must be present to justify the analogical connection, and how big and varied does the dataset need to be? For example, can the use of present-day and historical data relating to terrestrial vertebrate extinctions be extrapolated across all types of animal life to estimate total anthropogenic extinction rates, as Ceballos (2020) has done? The fossil record is comprised of only about 250k species out of an estimated four billion during Earth history. It is from this that the overall background extinction rate under non-mass extinction scenarios is ascertained. But as described in section 1.3.2.2, there is a tenfold difference (1000%) between the commonly cited upper and lower rates of 0.1-1 E/MSY. Dependent upon which side of the range is chosen as a point of comparison, present day extinction intensities can look very different. Jablonski (2005) cautions that the nature of the fossil record is such that palaeontological estimates should be applied to present-day situations with extreme caution. It is overwhelmingly biased towards marine invertebrates whilst instances of vertebrates, plants, and insects are drastically under-represented. Yet it is precisely these kinds of organisms that are most affected by the current crisis. The obvious question is, therefore, if the background extinction rate has major limitations due to data shortfalls, can it be used to gauge the severity of the current extinction episode? And if is used, despite major uncertainties, can or should it be viewed as *ex-ante* authoritative by non-natural scientists?

Clark and Szerszynski (2020) caution about the danger of social scientists and philosophers falling into scientism. That is, embracing insights from the natural sciences uncritically. By my reading, this is not uncommon with extinction material, particularly information relating to mass extinctions, as the data is often extremely complex. Haraway (1988:581) similarly warns of the "god trick" where science is assumed to be neutral and thereby taken at face value. By neutral, she means free of political or cultural influence emanating from the society that produces it, something she does not believe is possible. In his 2020 book, *Catastrophic Thinking*, science historian David Sepkoski explores the development of ideas around extinction since the late-18th century. He asserts that "Scientific understanding of extinction has changed quite dramatically over the past two hundred years, as have other aspects of Western cultural belief, and it is my adamant position that these changes have been linked" (Sepkoski 2020:Ch6). Similarly, when discussing the late-20th century biodiversity movement, Heise (2016:30) also believes "the cultural cachet that the concept of 'diversity' as accreted over the past half century in a variety of social spaces is hard to disentangle from scientific arguments". For both these authors, extinction and biodiversity science is not simply the production of objective data but also produces and is produced by cultural values (this will be explored further in the next chapter).

With a few notable exceptions (e.g., Kirksey 2015; Kohn 2015) the dominant anthropological response with much extinction-related science data and concepts is to accept it as established fact, specifically the notion we are in or entering the sixth mass extinction of species. See, for example, Rose (2011), Irvine (2020), and the recent Cultural Anthropology Fieldsights Forum (Münster et al. 2021), where within the introduction the editors "take the Sixth Extinction and its crises as a point of departure" with no analysis of the scientific data that resulted in such claims being made in the first place. Oreskes asks the pertinent question, "What are the relative risks of ignoring scientific claims that turn out to true versus acting on claims that turn out to be false?" (Oreskes 2019:Ch2). This, of course, is a major consideration found at the heart of much international environmental policy and discourse since the Brundtland Report proposed the idea of the Precautionary Principle[19] in 1987. But it is not simply a binary choice – social scientists can accept the warnings from extinction science at face value and proceed with their research accordingly. But any reflexive account of the impacts of extinction must surely aspire to investigate the empiricism of grand claims, particularly when humans (the primary subject of the social sciences) are prescribed with the force of an asteroid (Nixon 2014).

1.6 CONCLUSION

In this chapter, I set out to critically review the widely made proposition that humans have initiated the sixth mass extinction of species. If such an idea is correct, it would be a moment of profound ontological significance. It would be the first time in the known history of complex life that an individual species has caused a mass extinction; the first time a mass extinction has been driven by biotic forces; and it would confirm humans as geological agents whose activities in their scale influence match those of the Chicxulub asteroid, the impacts of which were described in graphic detail at the beginning of this chapter.

I have endeavoured to understand what mass extinctions are, what makes them unique, what we do and do not know about them, and why, through implication, humans as a species should be fearful of them. I have also tried to understand the boundaries of knowledge concerning present-day extinctions demonstrating the sheer complexity of extinction science. By positioning current extinctions concerns within a continuum of past events that have occurred over deep time (i.e., the designation of the "sixth", which has an implicit reference to those that have gone before), it invites us to step outside of human-centred timeframes to consider the long history of the planet. This includes the interplay of Earth processes and evolution and how they have shaped the direction of life over planetary history.

I did not seek to explore the drivers of the current extinction episode nor address the societal implications. I have focused more on the theoretical scientific aspects but with an awareness that extinctions are always situated and personal – they are felt locally by individual non-humans and humans, something I will discuss in the main conclusion. The intention has been to explore some of the vast scientific literature on mass and present-day extinctions, how they speak to each other, and how they ultimately shape our perception of both the environmental crisis and ourselves. Environmentally focused social scientists often take the direst of this material at face value. This, I speculate, might be explained by

19 The Precautionary Principle is, at its simplest, a modern restatement of the classical Hippocratic oath, "I will keep them from harm and injustice", which is often summarized as "first, do no harm". However, the precautionary principle is more than a dictum for individual actions; rather, it is intended to guide the behaviour of institutions and nations. And, unlike the Hippocratic oath and its modern equivalents, it applies to both human and environmental health (Hanson 2018).

its complexity but also because it fits the narrative of the biological world in crisis under modernity that many environmentally focused social scientists promote.

Critiquing this science is not tantamount to denying the seriousness of the environmental crisis. On the contrary. As Latour (2004) points out, the critic is not one who debunks, but one who assembles. The critic is not one who pulls the rug out from under the feet of the naïve believers, but one who offers the participants arenas in which to gather. By undertaking this analysis and proffering it within the anthropological realm, I hope it will stimulate the social sciences to engage more fully in the discussion rather than be mostly passive recipients of what is admittedly highly complex, time-consuming data.

Oreskes (2019) reminds us that expert consensus serves as a proxy. We cannot know if scientists have settled on the truth, but we can know if they have settled. With this in mind, what are we to make of extinction science? There is so much that is unsettled, and what is agreed upon is often little more than an admission of unknowability. Unlike climate change, there is no substantive knowledge baseline about the past or present, so extinction scientists perpetually argue it amongst themselves in the pages of academic journals, often revisiting decades-old arguments with widely divergent views. It's worth recounting some of the many aspects of extinction science discussed in this chapter that are either not agreed upon or are simply unknown. These include:

- The number of species on Earth
- The current rates of species extinctions
- The total number of species extinctions caused by humans
- Extinction rates in the past (background rates)
- Whether background rates can be used as analogues for the present
- Whether microbial life is affected and under threat
- Characteristics of prior mass extinctions (causes, durations, impacts, recovery times)
- Definitions of species and biodiversity

What is commonly agreed upon includes:

- The number of global eukaryotic species is decreasing
- Mass extinctions have been a regular occurrence during the Phanerozoic eon
- Mass extinctions have significantly impacted evolution, to the benefit of life as a whole
- The fossil record is unrepresentative of the number of species during Earth history
- The number of actual living species far exceeds (by an unknown amount) the number of described species
- Present-day species richness is higher than at any other point in the history of life
- Extinction for all eukaryotic species is the norm in Earth history and can be considered inevitable at some point

In the absence of extensive empirical evidence, extinction estimates are based on an educated guess about the number of existing species (unknown), the current rates of extinction (well known only for vertebrates), and the extinction rates in the geological past (inconclusive due to fossil record limitations). As has been described, each of these three elements suffers from a chronic shortage of reliable data, and it therefore seems impossible to identify if rates for current extinctions are above background levels for macroscopic life or by how much. It follows, therefore, that claims we are in the sixth mass extinction can only be speculative and without a strong scientific foundation. Despite this, Ceballos (2020) is adamant we are well into the sixth extinction. Barnosky (2011) thinks we are only on a pathway that will play out over hundreds or thousands of years. Jablonski (1994) thinks we are experiencing an intensification of background rates rather than a mass extinction (recall, mass extinctions have patterns beyond simple extinction intensification as described in sections 1.2.3.2 and 1.2.3.3).

Notwithstanding disagreements about extinction rates and the sixth mass extinction, it is widely agreed that the Earth is experiencing a major episode of terrestrial defaunation[20] with very particular patterns, such as the loss of small and large mammals (Dirzo 2014; Young 2016). Ripple (2017:10678) describes this as a "structural reordering of life on our planet". Some scientific commentators believe that combating defaunation rather than preventing extinctions should be the primary focus of conservation efforts (e.g., Brand 2015; Shellenberger 2020) as there are discernible social and ecological impacts that are often lacking within the analysis of absolute species disappearances.

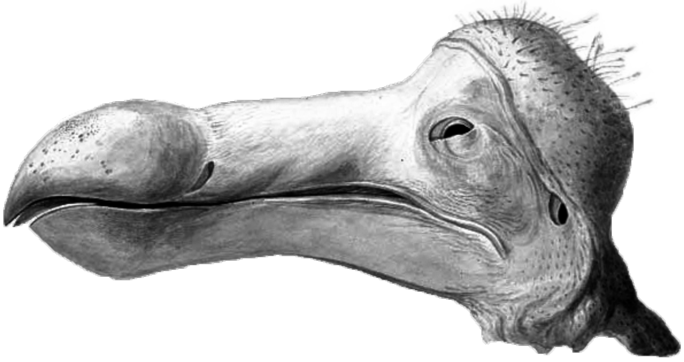
The sixth mass extinction idea was first introduced in 1992 by E.O. Wilson when he claimed humanity was rushing to eternity a large fraction of our fellow species in a single generation. Leakey and Lewin (1995) advanced this idea further by suggesting losses of up to 100,000 species per year. Setting aside the dubious scientific accuracy of these claims (itself a controversial scientific and ethical issue), I argue that framing extinction in this manner by these authors inadvertently undermined their primary intention – to raise awareness of the growing anthropogenic impacts on the Earth's biodiversity. Similarly, I believe it undermines the intention of contemporary extinction scientists who make the same claim for the same reasons. This is because mass extinctions have been a regular occurrence over the Phanerozoic eon (and perhaps before, though the evidence is still lacking) and have been a major component of macroevolution that has directly benefitted humans. The end-Cretaceous extinction 66 million years ago is the prime example – the demise of the dinosaurs cleared ecological space for the dominance of mammals. Only through this were our distant ancestors able to emerge. Evoking mass extinctions, therefore, risks naturalising

20 Dirzo (2014) adopts the term 'defaunation', which he likens to deforestation but for animals, noting that, unlike deforestation, it is fundamentally a cryptic phenomenon that is difficult to discern from observation of the actual landscape. Defaunation recognises that whilst extinction events are significant, they are a tiny part of biodiversity loss. By focusing on populations and global extinctions, there will be greater awareness of the processes of extinction and the magnitude of anthropogenic changes to global biodiversity.

environmental change – it forces us into deep time thinking but from a deep time perspective change under catastrophic circumstances that positively benefits some life forms, but not others, would appear to be the norm.

Extinction science purports to reveal a lot and, based upon the data produced by natural scientists from across a range of disciplines, grand claims are made about life on the planet both in the distant past and the present, including, of course, the extent to which it is being impacted by humans. As I have demonstrated, though, at almost every turn, there is a fundamental data shortage that would seem to confirm that many of the assertions amount to little more than guesswork.

This being the case, how is it that species extinctions and the idea of the sixth extinction have captured the scientific and public imagination? Surely it cannot simply be explained by an over-determination of the scientific data (though this may be part of the reason). In the next chapter, I will begin to explore this question. Via a reading of the long history of extinction research, I will show how the idea of the sixth extinction did not simply emerge out of nowhere. It resulted from over two centuries of debate and discussion involving combined direct and indirect factors – scientific, ideological, historical, and existential. These factors coalesced over time and resulted not just in the claim of the sixth extinction but also its particular inflexion, where concerns about biodiversity loss became bound up with fears about the disappearance of humans.



CHAPTER 2

EXTINCTION – CONCEPTUAL AND HISTORICAL PERSPECTIVES

2.1 INTRODUCTION

In chapter 1, I undertook a review of scientific data, exploring the proposition of a human-caused sixth mass extinction of species. As described, there are significant empirical deficiencies that make it very difficult to ascertain the scale of the current extinction episode, calling into question such a grand claim. I identified that information relating to three key variables was considerably lacking: the number of species on Earth, which is still fundamentally unknown; the background, ordinary rate of extinction over geologic timescales, which is not agreed upon by experts; and the current rate and number of disappearance of species, which is mostly speculative with little empirical evidence. These variables, in combination with one another, are key for assessing present-day extinction intensities. The lack of consensus on each makes it impossible to determine the scale of current species loss. Additionally, there is much that is unknown or indeterminate about prior mass extinctions. This raises the question of whether there is sufficient knowledge to use them as analogues for the present, complicating efforts to attain a relative understanding of contemporary species loss compared to mass extinctions over the past half-billion years.

Notwithstanding this, it is clear the idea of a sixth extinction has gained significant traction over recent decades across a variety of realms – academic, public, and journalistic, amongst others. But if the science is somewhat patchy and inconclusive, as I have demonstrated, what explains the attention given to such a major proposition? Surely concerns about a possible sixth extinction cannot simply be attributed to an over-interpretation of the scientific data?

This chapter will attempt to explore this question. I will describe how the popular interest in the sixth extinction is driven by a whole suite of factors, including scientific advances, ideological changes, global events, changing perceptions of the natural world, and existential anxieties. I propose that the sixth extinction proposition from the onset has been a crystallising concept that has brought together some of the broader environmental concerns about the state of the planet, including the possibility of human omnicide (self-extinction). I contend that if we want to fully understand the overarching concerns about species loss, we must excavate the deeper history of extinction theory as it has emerged and developed over the past two centuries, placed within the historical context of its day. This reveals a variety of tensions – epistemological, political, social, ecological – that extend beyond concern for lost species themselves, and which have grown and changed over time, sometimes quite dramatically.

The chapter is essentially split into two parts and, for ease of understanding, will mostly weave a chronological narrative. The first part, charting the period from 1796 and the first 'discovery' of extinction by Georges Cuvier until the publication of Charles Darwin's *On the Origin of Species* in 1859, will explore early scientific ideas about extinction as they emerged at the same time as radical new understandings about the age of the Earth. This culminated in Darwin incorporating extinction within his theory of evolution by natural selection, where it was conceptualised as part of a betterment process of nature constantly improving itself over time. At this point, biologists gave extinction a positive valence: it was necessary, and even good, for the maintenance of a stable economy of nature. Significantly, there was no sense of loss when species disappeared – it was the price of evolutionary progress. This clearly contrasts strongly with current ideas about extinction, which is now commonly viewed with dismay and even horror. The second part of this chapter, covering the period from about 1950, will endeavour to chart this transformation in viewpoints from Darwin's day to the end of the 20th century just before the emergence of the Anthropocene concept. It will map and describe how advances in theories and ideas about mass extinctions, scientific developments from the military realm that led to a new vision of the biosphere as a space of complex ecological interactions, Cold War societal fears about nuclear annihilation, awareness of growing anthropogenic impacts upon the planet, the emergence of the biodiversity concept and the recognition of the importance of genetic diversity, and knowledge that humans have been driving elevated amounts of species loss all coalesced within a narrow time window. I contend that these elements, in combination with one another, contributed to the initial proposition of the sixth extinction in 1992, where the extinction of species and the potential disappearance of humans effectively became conjoined. Humans came to be seen not just as a threat to other species, but also to themselves.

It should be recognised that the many points I will note are just some of the elements one finds when sifting through the historical record. There is no doubt that many others could also be included in the discussion. It seems clear there is much-unrealised potential in exploring the long history of extinction thought situated within the circumstances of its day. In that regard, the chapter will probably not come close to realising its full potential. It will, however, help us understand the popular interest in the sixth extinction proposition and how it is the culmination of a broad variety of scientific developments and societal concerns that have emerged over the past two centuries.

2.2 EARLY CONCEPTIONS OF EXTINCTION

It is a surprising fact that from antiquity until the end of the 18th century, there was no agreement that any species could permanently go extinct. From the Ancient Greeks through to the Enlightenment,[1] it was considered that all that disappeared would eventually return. The Principle of Plenitude (Lovejoy 1936), which can be traced back to Plato (428-348 BCE) and endured into the 19th century, held that nature would always be full of the things it could possibly contain and that nothing could ever truly go extinct as this would leave a gap in the space of what was possible.[2] Animals were noted to disappear, but it was considered these were mere "intervals of quiescence" and that reappearance was guaranteed (Moynihan 2020:Ch3). This helps explain why the disappearance of the dodo in 1662 was not noticed until the 1830s. Plenitude also provided a teleological justification for exploitation and loss. Destruction was just a way nature maintained and replenished itself so it could go on and create more through eternity.

Before the 19th century in Europe, the dominant theory of nature was the idea of the 'Great Chain of Being' (image 2.1). This was a medieval Christian concept, traceable to Aristotle (384-322 BCE) and his Scala Naturae,[3] that stated nature was organised in a strict hierarchy. Minerals were at the bottom, God was at the top, and humans were near the top, immediately below angels. The structure was immutable and unchangeable and there was no possibility of movement between levels. Extinction was theologically impossible, as it was thought God would never destroy his own creations. The Great Chain of Being idea conditioned European understandings of nature and lay behind the belief God had given humans dominion over it. In conjunction with the Principle of Plenitude, it ensured that extinction was not accepted as fact until the end of the 18th century, centred around a better understanding of animal fossils and a creeping suspicion that the Earth could be much older than was conventionally thought.

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1 The Enlightenment – the great 'Age of Reason' – is commonly recognised as the period of rigorous scientific, political, and philosophical discourse that characterised European society during the 'long' 18th century: from the late 17th century to the ending of the Napoleonic Wars in 1815. This was a period of huge change in thought and reason, which was decisive in the making of modernity (something that will be discussed in chapter 3). Centuries of custom and tradition were brushed aside in favour of exploration, individualism, tolerance, and scientific endeavour, which, in tandem with developments in industry and politics, witnessed the emergence of the 'modern world' (White 2018).

2 The ancient Principle of Plenitude, which, stated simply, says that all legitimate possibilities are eventually realised. In his seminal 1936 book, *The Great Chain of Being,* philosopher Arthur Lovejoy was the first to trace the influence and persistence of this notion across Western intellectual history from the Ancient Greeks onward. He established that Plenitude has been a persistent background assumption of Western thinking, either implicitly or explicitly, all the way back to Plato. It is the assumption there is nothing that can be realised in nature that somehow forever fails to be realised. This of course means that none of nature's species can permanently disappear. The possibility of the species reappearance will inevitably be realised at some later point.

3 The Scala Naturae, or the "Natural Ladder", is the idea that the entire natural world could be arranged in a single continuum. During the medieval period, this was incorporated into the idea of the Great Chain of Being.

IMAGE 2.1 The Great Chain of Being
Illustrator: Valades, Didacus (1579), reproduced from Wikipedia (2021)
A visual metaphor for a divinely inspired universal hierarchy ranking all forms of higher and lower life. Humans are in the second row; hell is at the bottom. The great chain is central.

Huge bones and teeth from unknown fauna had been discovered throughout the Middle Ages and into the 17th century, but mostly it was thought they were remnants of Noah's flood or placed there by God in the preceding millennia. By the 1750s, many naturalists accepted the organic nature of fossils, but the possibility of them being from extinct animals was denied, as Christians simply could not perceive any design error by the creator. It was thought the animals had simply migrated to somewhere else on the planet. Thomas Jefferson (1743-1826), who had a lifelong obsession with mammoths and was an avid collector of their remains, retained a conviction over his lifetime that they were still alive somewhere in North America. Fossils were so abundant in certain rock formations that the material was comprised of little else. A good example, well known through traveller reports of the day, was the limestone used in the construction of the Pyramids of Giza that was teeming with the remains of former marine life (Benton 2015).

The lack of osteological studies[4] up until the late 18th century made it difficult to confirm whether fossil specimens were remnants of existing species or variations of them. This changed through the work of Georges Cuvier (1769-1832), French zoologist and naturalist, often referred to as the founder of palaeontology. In 1796, Cuvier was the first to prove empirically that fossils were from extinct animals. He did this by closely studying the molars of mammoths (found in huge numbers in Siberia during the 18th century) and demonstrated they were not the same animals as elephants, bringing to the discussion the technique of comparative anatomy[5] using unprecedented precision (image 2.2). Until this point, many savants interpreted mammoth fossils as simply the remains of elephants swept north from India during some kind of deluge. Cuvier, through his careful analysis, proved otherwise, identifying that they were a different species. He scoffed at the idea that living members of these fossil species were lurking somewhere on Earth, unrecognised – they were simply too big to go unnoticed. Instead, Cuvier declared they were separate species that had vanished.[6]

Cuvier's use of anatomical analysis, his skills as an illustrator, and his unprecedented insight settled a major debate of the day about whether species could disappear. He was the first to succeed in establishing extinction as fact, since at the time it was considered by many of his contemporaries to be pure speculation. He then proceeded to make a further revelation that helped to revolutionise science, transforming ideas about the age and history of the Earth and the origins of life upon it. Much as Darwin is normally credited with being the first person to devise a theory of evolution, as we will see, so Cuvier can be credited with being the first to theorise extinction as part of a doctrine that came to be known as 'catastrophism'.

4 The detailed study of the structure of bones, skeletal elements, and teeth.

5 Comparative anatomy is the comparative analysis of the body structures of different species of animals. It is used to understand the adaptive changes they have undergone during the course of evolution from common ancestors. In Cuvier's time (before any established theory of evolution), it was simply used to identify the difference between animal remains.

6 It is now known the last mammoths disappeared 4,000 years ago in Siberia (Martin 2007).

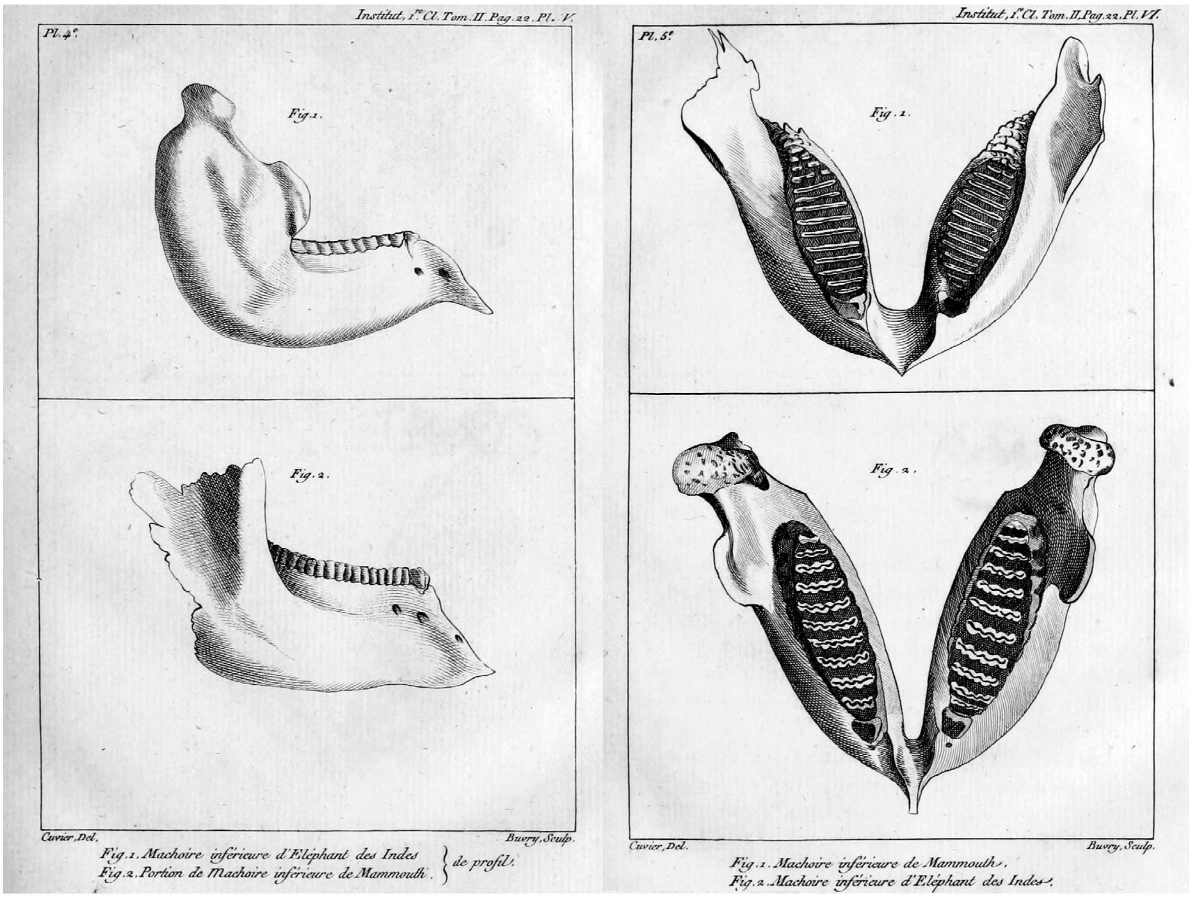


IMAGE 2.2 Figure of the jaw of an Indian elephant and the fossil jaw of a mammoth
Illustrator: Cuvier, Georges (1796), reproduced from Rudwick (1997)
A 1796 paper by Cuvier contained this illustration showing the differences between the lower jaws of a mammoth (top) and an Indian elephant. These differences underpinned Cuvier's proposition that mammoths had gone extinct.

2.3 CATASTROPHISM AND THE FIRST THEORY OF EXTINCTION

In his first lecture about extinction in 1796 at the National Institute of Science and Arts, in Paris, Cuvier intimated that he knew the driving force behind it, if not the exact mechanism. He proposed that mammoths had been wiped out by a catastrophe. He hesitated to speculate about the precise nature of the calamity – "It is not for us to involve ourselves in the vast field of conjectures that these questions open up" (Cuvier 1796, as cited in Kolbert 2014:ChII) – but he thought there had been a major disaster. He also made a radical assertion that there was a world that existed before human presence, something that represented a major challenge to religious orthodoxy.

> All these facts, consistent among themselves, and not opposed by any report, seem to me to prove the existence of a world previous to ours, destroyed by some kind of catastrophe. But what was this primitive Earth? What was this nature that was not subject to man's dominion? And what revolution was able to wipe it out to the point of leaving no trace of it except some half-decomposed bones? (Cuvier 1796, as cited in Rudwick 2005:363).

If there had been "a world previous to ours" then it ought to be possible to identify traces of other extinct species. So, he set out to find them. In the proceeding years, and following extensive fieldwork, Cuvier discovered sequences of fossils layered within the strata of the Paris Basin,[7] which seemed to provide evidence for further extinct species. Observing how each layer of strata was populated by very different and unfamiliar plants and creatures, he began to speculate that the Earth had played host to different regimes of flora and fauna at different periods in the past. Close inspection of the stratigraphic layers, and the discovery of new and strange looking fossils, led Cuvier to conclude the Earth had changed dramatically over time and was in fact a succession of former worlds. He guessed that each of these worlds had been truncated by a planetary catastrophe that had extinguished all living species. After each catastrophe, the world would begin again with a new set of laws and conditions and a completely new set of species. He did not reveal where the new species came from, and there was no suggestion of them being connected to those that had disappeared before. Life simply started afresh all over again.

Centred around his analysis of secondary rock formations[8] in the Paris Basin and the fossils he discovered there, Cuvier conceived a whole new way of thinking about the Earth. He speculated that in the past, strange destructive forces had acted with an order of magnitude wholly incomparable to those currently observable. He was also claiming that the conditions of life were neither stable nor uninterrupted – species came and went over time and that the surface of the Earth was in a perpetual state of transformation. Extinctions were not rare – they were common.

His ideas had two major implications for humanity. First, the violent paroxysms of the Earth and the periodic destruction of successive worlds suggested humans were as at risk of extinction as any other species. This was one of the first speculations of human extinction as a naturalistic possibility, bound up with the disappearance of all other species. Second, no human bones or fossils were found within the rock strata of his study sites, which pointed towards them being newcomers within a much longer history of life. This represented a major challenge to religious orthodoxy. The creation narrative of *Genesis* implied the universe contained a human presence from the onset. The idea of a much broader cosmic history encompassing the Earth and life itself was not considered possible. Up until the late 18th century, before there was an understanding of deep time, the Earth was still considered to be very young, and most people adhered to 4004 BCE as the biblical dawn of time, as determined by the Irish archbishop, James Ussher (1581-1656). There had been suggestions the Earth may be older – Georges Buffon (1707-1788) for example speculated that it may be 75,000 years old – but it was generally considered that the age of the Earth and the age of humans were one and

7 The Paris Basin is one of the major geological regions of France. It developed during the Triassic period (50-252 Mya) over remnant uplands of the Variscan orogeny, covering an area of approximately 140,000 km^2.

8 Rocks composed of particles derived from the erosion or weathering of pre-existing rocks, such as residual, chemical, or organic rocks formed of detrital, precipitated, or organically accumulated materials.

the same, in accordance with the Bible. Cuvier's ideas contradicted this. His discoveries led him to believe that the age of the Earth was much older than Ussher had proposed (though Cuvier did not place an exact value on it, simply believing that it was very old), and in a break with religious orthodoxy, he believed human and Earth history were not coterminous. Humans had arrived on the scene much later and, he speculated, they were only 10,000 years old (Rudwick 2005).

IMAGE 2.3 Georges Cuvier
Artist: Vincent, François-André (1800), reproduced from Wikipedia (2021)

Suggesting that extinction was part of the regular course of nature was also a break from the idea of the Great Chain of Being, itself tantamount to supporting atheist views. Cuvier, however, who was a devout Christian, did leave the door open for the creationist view of species origins, remaining silent on the new source of them following each catastrophe. He also endeavoured to harmonise some of his ideas with the Bible, equating the most recent catastrophe with *Genesis* (Rudwick 2005). This left him open to accusations of supernaturalism, something sober naturalists of the day were trying to expunge from their theories, and provided easy ammunition for his critics who alleged he was practising a form of 'biblical geology' (Sepkoski 2020).

Cuvier was undoubtedly the most important early proponent of biological extinction, and his views – presented within his accounts and lectures – helped legitimise ideas of extinction not just among fellow naturalists, but to a wider educated public in Europe and North America. He was the first to prove extinction was a genuine phenomenon and before his research, no species was classified as extinct. He was also the first to theorise the causes of extinction, published in his *Essay on the Theory of the Earth* (Cuvier 1813) where he proposed that now-extinct species had been repeatedly wiped out in successive catastrophic Earth revolutions.

Some of Cuvier's wildest-sounding claims have turned out to be surprisingly commensurate with contemporary understandings of evolution. Nature does, on occasion, "change course", and at such moments it is as if the "thread of operations" has been broken (Rudwick 2005:586). The modern-day term for the cataclysms is, of course, mass extinctions. He was also the first to raise the spectre of permanent human extinction, an often-overlooked aspect of his work that was itself of great historical significance. Cuvier's idea that the natural history of the planet had been punctuated by major geophysical revolutions that have fundamentally altered the composition and way of life on its surface was eventually termed catastrophism.[9] It was one of the two main ideas of the day postulating a deeper history of the Earth than religious orthodoxy allowed for. The other was uniformitarianism.

2.4 UNIFORMITARIANISM

Whereas Cuvier sought to explain the history of the Earth through the idea of successive revolutionary catastrophes, the counter-theory to this violently paroxysmal vision of the past was preached by the uniformitarians. Uniformitarians thought the surface of the planet, and the life upon it, had been formed by slow, gradual changes occurring over infinitely long timeframes. Uniformitarianism,[10] as it eventually came to be known, was made famous by

9 The term 'catastrophism' was first coined in 1832 by William Whewell (1794-1866), one of the early presidents of the Geological Society of London.

10 The term 'uniformitarianism' was conceived in 1832, also by William Whewell (1794-1866). It was meant to convey Hutton's sense of order and regularity in the operation of nature and Lyell's sense that there was a uniformity of rates of geological processes through time.

Charles Lyell (1797-1875) but many of the foundational ideas behind it were conceived by James Hutton (1726-1797) in his book *Theory of the Earth,* published in 1788. Hutton is often referred to as the founder of the discipline of geology and the "inventor" of deep time. Like Cuvier, he advanced the idea that the history of the Earth could be inferred by observation of rock strata. Through his fieldwork in Scottish landscapes, he developed the theory that geological features underwent perpetual transformations over very long time periods. From this, he argued, the Earth could not be young. He thought the cosmos had no origin and no end, and time was, in fact, infinite. Hutton's most famous words are those which end the book, when in relation to the age of the Earth he stated, "we find no vestiges of a beginning and no prospect of an end" (Hutton 1788, as cited in Irvine 2020:Ch1). His vision was of a perpetual world, devoid of catastrophes, where the planet underwent slow change but only as part of the process of recycling back to the same. There was effectively no history – everything was just a gradual repetition of what went before.

Though some of the core ideas of uniformitarianism were first suggested by Hutton, it only came to be widely known from 1830 onwards, years after his death, with the publication of Charles Lyell's *Principles of Geology: Being an Attempt to Explain the Former Changes of the Earth's Surface by Reference to Causes Now in Operation*. Lyell took Hutton's ideas of an infinite Earth and laid them out in more detail. His key innovation was linking the history of life to the process of gradual geological change. In this way, the Earth existed in a sense of dynamic equilibrium – always changing, but always staying the same over geological time. As the title of his book implied, he also argued that every geological phenomenon could and should be explained by modern processes and causes alone. This is the key principle of uniformitarianism: "the present is the key to the past" (Lyell 1830, as cited in Benton 2015:Ch3). The prohibition on causes that cannot be observed in the present sought to remove any historical religious and other supernatural causes from the geosciences. It also automatically excluded the possibility of major, Earth-shattering catastrophes in the past as proposed by Cuvier on the basis the forces behind them could not, Lyell believed, currently be observed. This included mega-tsunamis, major volcanic eruptions, global floods, asteroids, and other speculative phenomena.

Lyell accepted extinction as a normal (but rare) occurrence, albeit at a pace too slow to be discernible. Surprisingly, even though he was part of a progressive movement of the day trying to expunge supernaturalism from scientific discussions, he was reluctant to preclude vanished species eventually returning at some point in the future as part of the cyclical processes of the Earth. For the dinosaurs, he famously speculated, "the huge iguanodon might reappear in the woods, and the ichthyosaur in the sea, while the pterodactyl might flit again through the umbrageous groves of tree-ferns." (Lyell 1830, as cited in Moynihan 2020:Ch3). He was lampooned for such a dubious claim and his colleague and fellow geologist, Henry de la Beche (1796-1855), sketched a humorous cartoon mocking the idea (image 2.5).

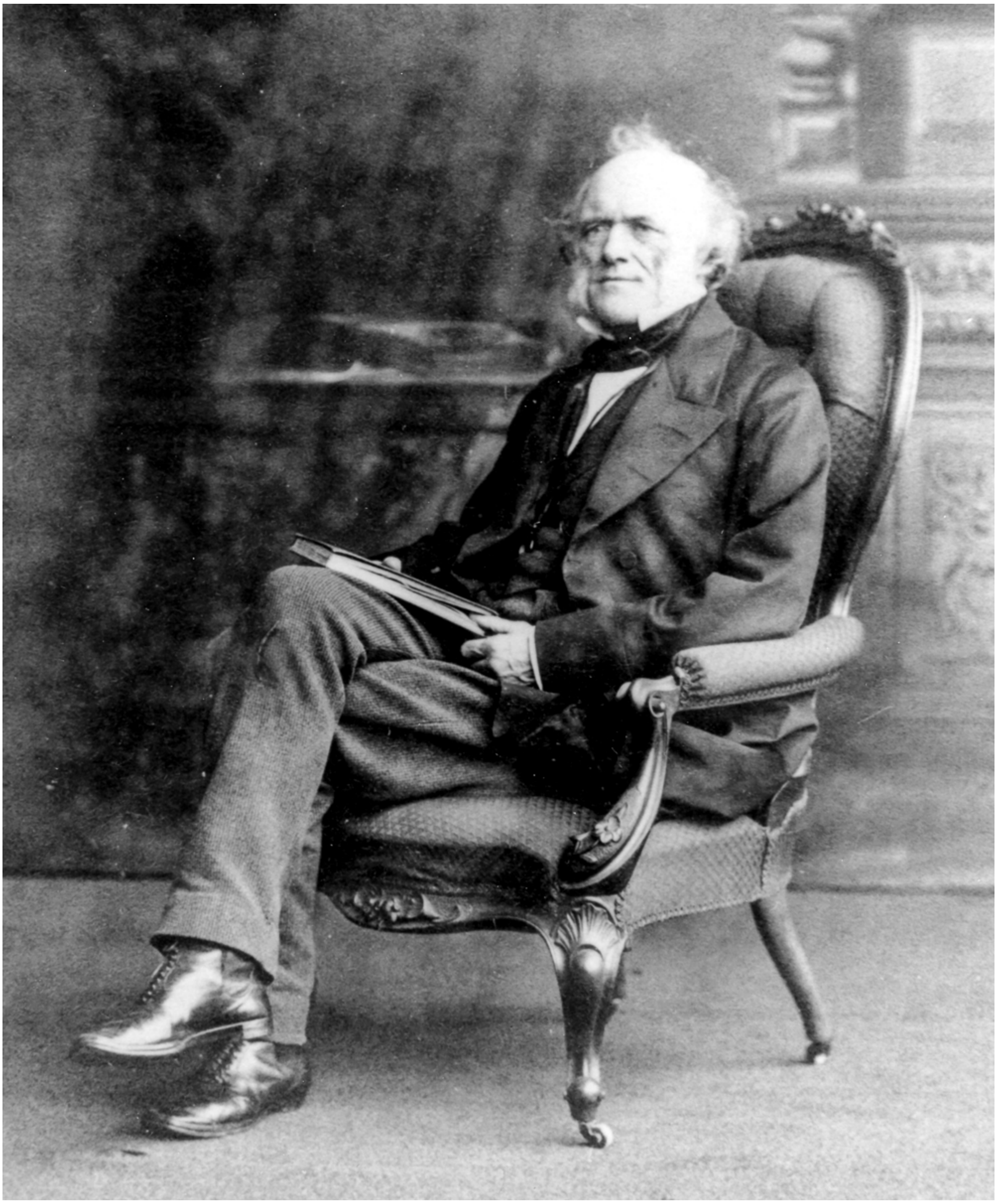


IMAGE 2.4 Charles Lyell
Photographer: Edwards, Ernest (1863), reproduced from the Darwin Correspondences Project (2021)

Whilst Lyell did not rule out species one day reappearing, he did, contrary to Cuvier, rule out their sudden mass disappearance. He explained discontinuities in the fossil record (i.e., the gaps in the rock strata that contained no fossils – a signature of major extinction episodes) as being simple artefacts of periods of the non-deposition of fossils, exacerbated by long periods of erosion. In his (and later Darwin's) formulation, extinction was a very lonely affair. Each species that had vanished shuffled off all on its own.

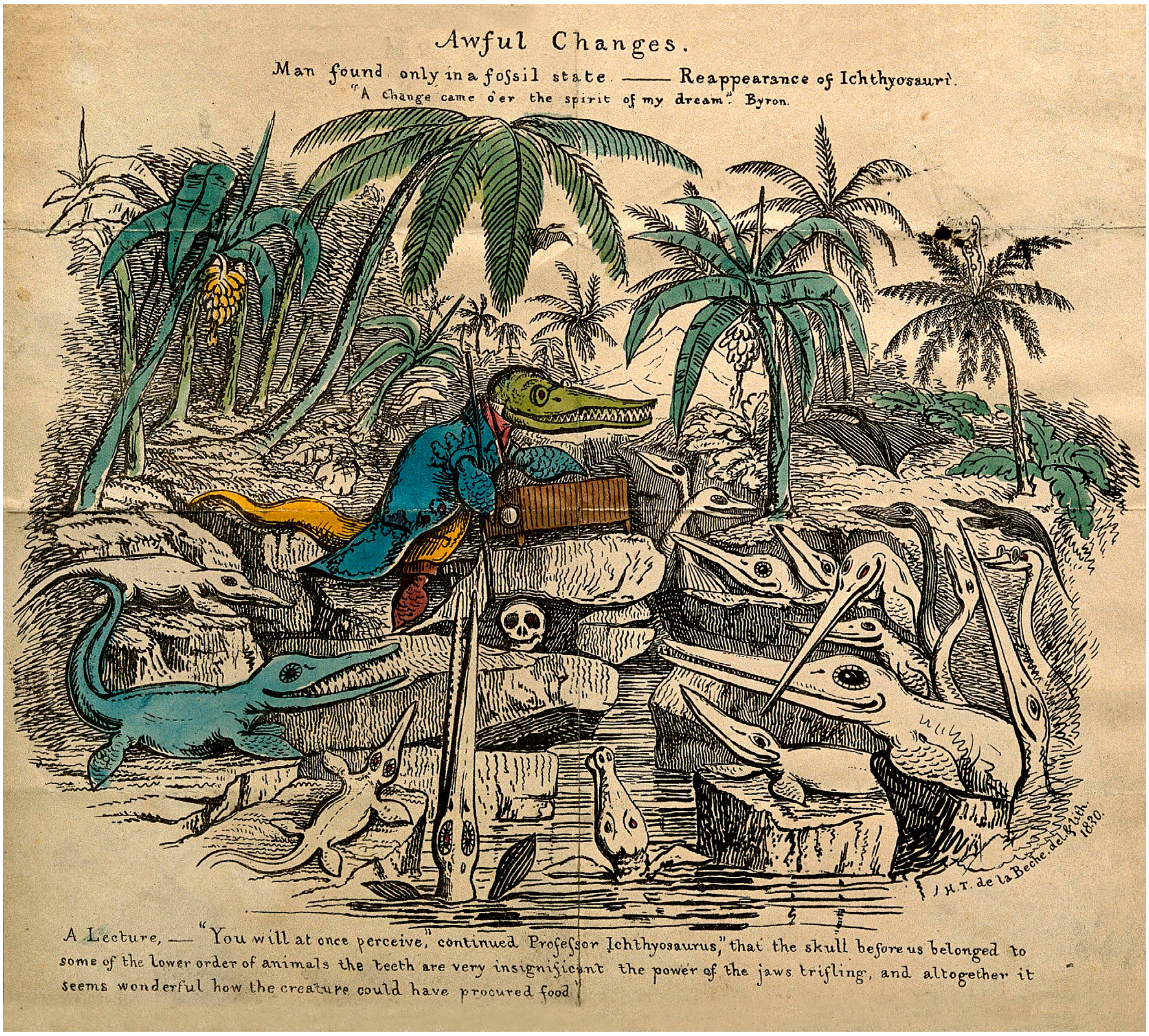


IMAGE 2.5 Awful Changes. Man found only in a fossil state – Reappearance of Ichthyosauri
Illustrator: de la Beche, Henry (1830), reproduced from Wikipedia (2021)
The cartoon makes fun of what was considered the outlandish concept, put forward by Lyell, that geological and biological history was cyclical and therefore extinct animals could return to the Earth.

Though Lyell was an acquaintance of Cuvier and spent time with him discussing ideas, it did not prevent him from attacking catastrophism, dismissing it as unscientific and casting Cuvier as a great speculator. He succeeded in setting up a false dichotomy between uniformitarianism and catastrophism despite both sharing the same radical ideas that the age of the Earth was much older than conventionally thought and that the epochs of nature could be inferred from geological strata, rather than the Bible. They differed in their ideas about how the layers should be interpreted. Cuvier thought the changes in each of the sedimentary layers was due to a major geophysical revolution triggered by cataclysms. Lyell dismissed this as wild speculation, not least because no evidence could be produced to support such a claim. He, like Hutton before him, believed the layers could be explained by the slow, cyclical changes of erosion, deposition, uplift, and subsidence in the natural world over indefinite periods of time.

Critiquing uniformitarianism, Moynihan (2020) has argued that it was effectively the ancient Principle of Plenitude in another form. This because the idea of the perpetual recycling of nature over geological timescales precludes anything ever being truly historical. A historical account must be ready to allow for events and processes that differ from those currently observable (such as mass extinctions), or one is in a state of eternal stasis. Rudwick (2005:118) similarly considers uniformitarianism, with its notion of endless repetition of currently observable processes, as ahistorical, suggesting it was "as profoundly unmodern as the short [biblical] timescale."

Until the publication of Lyell's *Principles of Geology* in 1830, Cuvier's theory was the leading scientific doctrine for explaining the natural history of the planet and the causes (if not the mechanisms) of extinction. Thereafter, uniformitarianism took over and catastrophism quickly went out of fashion as the Victorian era dawned. It became synonymous with poor science owing to its religious connotations and because advocators of it were unable to produce concrete empirical evidence to support their claims that the Earth had been subject to sudden, violent events in its deep past. It thereafter became difficult to study mass extinctions within the bounds of normal science. For over 130 years, until new research exploring the disappearance of the dinosaurs, anyone deviating from gradualist interpretations of the Earth and focusing on catastrophic and sudden violent events were considered "heterodox and bizarre researchers, if not charlatans" (Pievani 2014:86).

We now know that Lyell, Hutton, and other uniformitarianists of the day were wrong in certain key respects. The age of the Earth is not infinite. It is 4.5 billion years old. And nature is not uniform – it is constantly in flux and forever changing. Contrary to Cuvier, we also know that whilst catastrophe has profoundly influenced the life of the planet, not least through mass extinctions, few of the sedimentary changes in the geological record are attributable to sudden, violent events. In fact, overall, the Earth is neither uniform nor catastrophist, but a combination of both. There have been periods of major global change over geological time, including planet-wide glaciation, extensive volcanism, and meteors. But there have also been times of relative stability, such as during the early-mid Pliocene epoch (3-5.3 Mya).

Pending the 1980s discovery that the dinosaurs were wiped out by a giant asteroid, which gave birth to what came to be termed "new catastrophism" (Benton 2015), the uniformitarian approach became the normative methodology within geology and palaeontology for 150 years, generating a reluctance to accept the possibility of catastrophe and thereby mass extinctions. At the time of Lyell's formulation of it in 1830, though, it lacked one key component: an explanation of how species appeared. That is, a theory of evolution. Whilst Lyell accepted evidence from the fossil record that species occasionally went extinct, he refused to speculate on how species formed, portraying it as an infrequent occurrence that could never be observed. Similarly, Cuvier was interested in how species became extinct, but had no interest in how they appeared. Unlike Lyell, he was explicit in his objection to the concept of evolution, repeatedly emphasising that his extensive experience with fossil material indicated one fossil form does not, as a rule, gradually change into a succeeding distinct fossil form. Darwin, drawing upon Cuvier's discovery of extinction and Lyell's uniformitarianism views of gradual Earth processes stretching backwards over infinite time, took both ideas and incorporated them into his groundbreaking theory of evolution by natural selection. In doing so, he provided the first explanation of the relationship between the appearance and disappearance of species, transforming the understanding of the history of life.

2.5 DARWIN AND EXTINCTION

Charles Darwin (1809-1882), like other naturalists of his time, was intrigued by the fossils of extinct animals and plants, found in increasing numbers since the 18th century. His observation of these fossils and his comparison of them to living species during his Voyage of the Beagle between 1831-1837 contributed to the development of his proposition that all life on Earth had evolved from a few common ancestors (image 2.6). His evolutionary theory, which he published twenty years later in 1859 as *On the Origin of Species,*[11] was a response to some of the main debates of the day amongst fellow naturalists, centred around the mysteries of the fossil record. The core issues Darwin sought to address in his theory were:

- The origin of new species that continually appeared throughout the record
- How to explain the presence of organisms in the record that could no longer be found
- Why species were distinct when they first appeared

He responded to these questions by proposing that:

- The process of the evolution of existing species leads to the formation of new ones
- Species go extinct following a gradual process of decline associated with competition over finite resources and extinction is the fate of those who cannot compete
- Life is progressively responding to its environment and thereby always changing and improving itself. This gives rise to new forms of life

Darwin was strongly influenced by the work of the uniformitarianists and, after publishing his account of his time on the HMS Beagle in 1839, wrote, "I always feel as if my books came half out of Lyell's brain" (Darwin 1839, as cited in Kolbert 2014:Ch3). Darwin added to uniformatarianism the regular cycle of extinction and speciation, which made his view of nature considerably more transient than earlier conceptions of a mostly static balance or economy. However, beneath this constant change, he believed there was a fundamental underlying stability because of nature's capacity for endless self-generation of more diversity.

11 The book's full original title was, *On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life*. In the 1872 sixth edition, his final version, "On" was omitted.

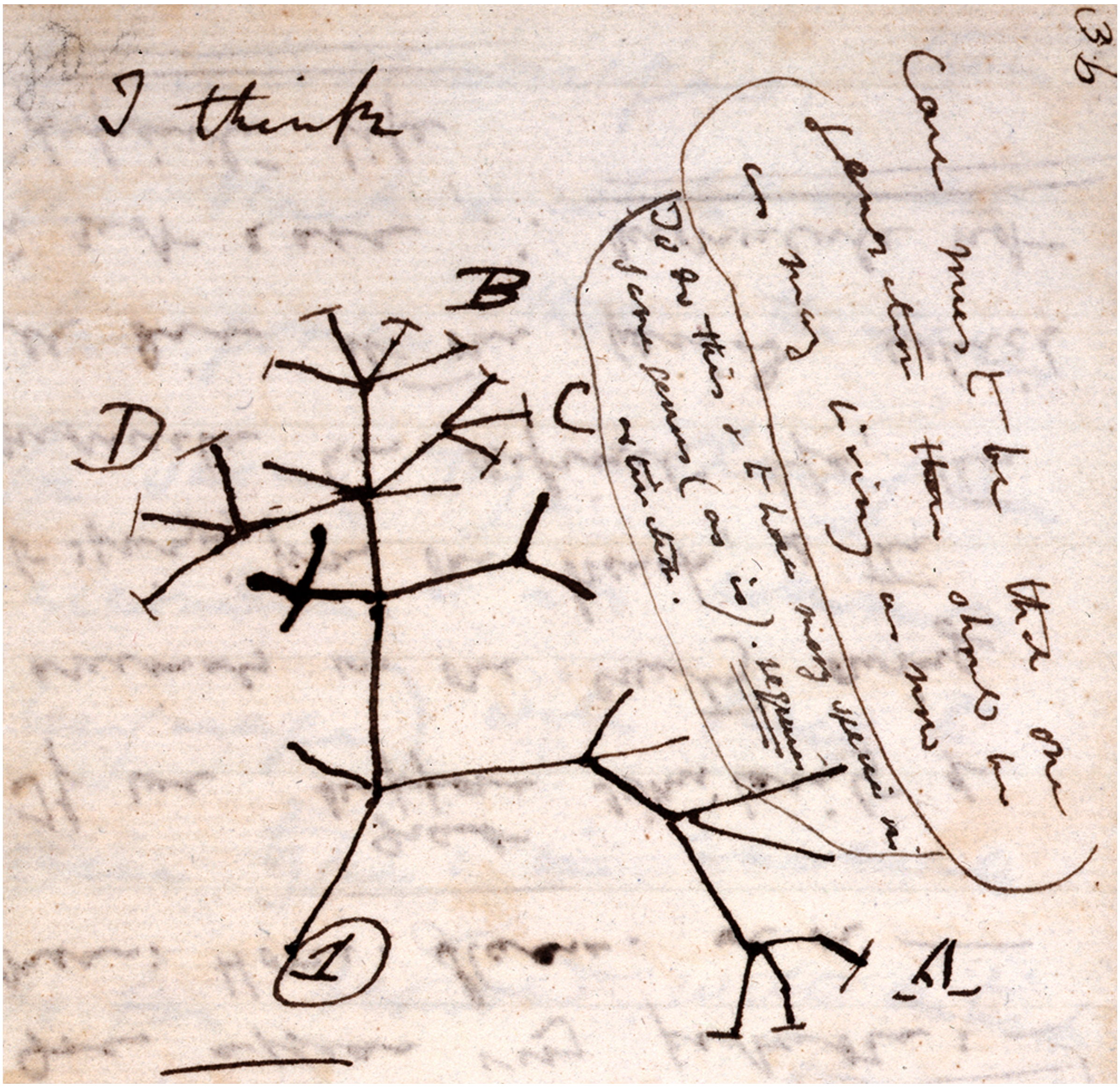


IMAGE 2.6 The tree of life
Source: Darwin, Charles (1837), reproduced from the Darwin Correspondences Project (2021)
Darwin's sketch from his *Notebook B: Transmutation of Species*. Because of Horizontal Gene Transfer (HGT), discussed in chapter 1, we now know this depiction is not strictly accurate. Genetic material can move laterally between unicellular and/or multicellular organisms other than by the transmission of DNA from parent to offspring. HGT is an important factor in the evolution of many organisms and has been described as the real origin of species (Quammen 2018).

On the Origin of Species is not itself a book about extinction. Despite Darwin's profound interest in it, "No one I think can have marvelled more at the extinction of species than I have done" (Darwin 1859:ChXI), the word does not appear in the index. He believed extinction was essentially the flip side of natural selection – the elimination of the unfit – and required no independent causal explanation or analysis. In his own words, "The theory of natural selection is grounded on the belief that each new variety, and ultimately each new species, is produced and maintained by having some advantage over those with which it comes into competition; and the consequent extinction of less-favoured forms almost inevitably follows" (Darwin 1859:ChX). What appears to be extinction is, in fact, evolution by another name. What appears as death is actually part of a process of continuation, because, more often than not, "the improved and modified descendants of a species will generally cause the extermination of the parent-species" (Darwin 1859:ChX). Extinction is here part of the process of betterment, as species come to replace their "less improved parent" (Darwin 1859:ChX).

It is worth drawing out the full significance of this. For Darwin, extinction was a positive good, as it acted for the improvement of species (or races). There was no sense that anything was really being lost, as nature was simply improving its stock and what came after would be inevitably superior. In other words, extinction was something to be celebrated, not mourned. It was the price of evolutionary progress.

Though Darwin was familiar with Cuvier's work, like Lyell, he rejected the idea of mass extinctions, believing instead that, "species and groups of species gradually disappear, one after the other, first from one spot, then from another, and finally from the world" (Darwin 1859:ChX). There are several historical explanations for this position. First, the evidence of slow geological change seemed at odds with the major geophysical revolutions proposed by Cuvier, which were impossible to prove. Second, the idea of mass extinctions was still tainted by their association with catastrophism, which many scientists connected with natural theology.[12] Third, the known fossil record of the day was relatively poor. Though he was aware of gaps in the secondary rock formations (recognised now as evidence of mass extinctions), Darwin believed this was down to incomplete knowledge and that somewhere on the planet, the absent information would eventually be discovered.

Another key aspect of Darwin's view of extinction, which was a key deviation from Lyell, is that he thought the extinction of a species was permanent (recall Lyell was mocked for his suggestion the ichthyosaurus might one day return). He made it clear that irreversibility was at stake, "when a species has once disappeared from the face of the earth, we have reason to believe that the same identical form never reappears" (Darwin 1859:ChX). As noted, though, there was no sense that this permanence constituted an overall degradation of nature.

Darwin treated the relationship between extinction and the emergence of new species through speciation as being in dynamic equilibrium and argued that the total number of species remained stable over time, thus maintaining the overall "economy of nature" (Darwin 1859:ChIII).[13] We now know this to be wrong – over geologic timescales, the number of taxa has steadily increased (see chapter 1, diagram 1.2). We also know that species sometimes disappear en masse due to violent Earth forces that cause dramatic drops in standing

12 Traditionally, natural theology is the term used for the attempt to prove the existence of God and divine purpose through observation of nature and the use of human reason.

13 Darwin repeatedly uses the expression "economy of nature" in *Origins*. He was not the first to conceive nature as an economy, though he was among the first to suggest an explicit similarity between natural and political economy.

diversity, such as the end-Permian mass extinction 254 Mya when an estimated 96% of species went extinct. Post-mass extinction recoveries, when natural selection is relaxed and reduced evolutionary competition, also result in steep rises in speciation, sometimes spread over millions of years.

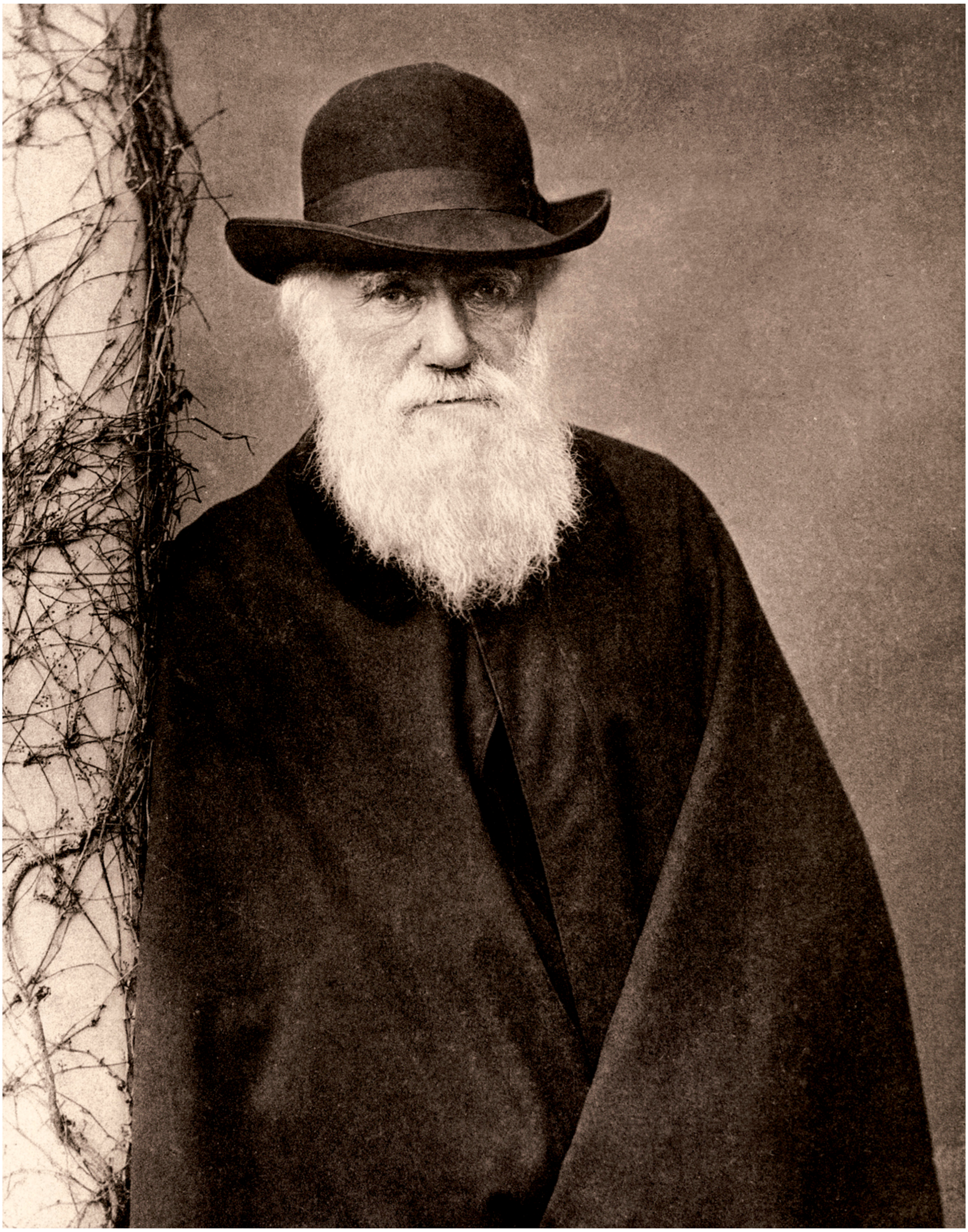


IMAGE 2.7 Charles Darwin
Photographer: Cameron, Julia Margaret (1881), reproduced from Wikipedia (2021)

Overall, we can say that Darwin's work established a view of life both enabled and effaced by extinction. This allowed for the conceptualisation of each species' uniqueness and the development of biological thought based on how the conditions of life also un-work themselves. Though it has been suggested he downplayed the evolutionary significance of extinction in *Origins* (Sepkoski 2013), by incorporating it into his evolutionary theory, more than anyone else to that point, he gave it widespread legitimacy. The book was written for a non-specialist audience and attracted broad interest upon publication. Darwin was already highly regarded as a scientist, so his ideas were taken seriously (Reznick 2011). His proposition constituted a dramatic change from late 18th century ideas when, prior to Cuvier, there was no recognition that any species could permanently go extinct. In little over sixty years, extinction had moved from being denied to being welcomed as a key element of the processes of the Earth.

There are several biological, social, and philosophical implications of Darwin's ideas that are worth emphasising. In combining the idea that newly evolved species would be an automatic improvement on any species that became extinct, Darwin was introducing a wholly new conception – the idea of evolutionary progress. Not only did his theory naturalise extinction as part of normal life processes, but it also gave it a positive moral valence: it was necessary, and even good, for the maintenance of a stable economy of nature. Although Darwin denied natural selection produced perfection – indeed, he showed it could sometimes be vouched for precisely by its imperfections, such as the eye or the bee's sting – he saw the principle of natural selection as essentially enhancing and improving the organic inhabitants of the Earth. He states, "New and improved varieties will inevitably supplant and exterminate the older, less improved and intermediate varieties" (Darwin 1859:ChXV). So, for him, extinction was a winnowing, a process that makes space for a richer harvest and seedtime. This process was independent of any human impacts. Nature was inherently self-renewing, self-improving, and required no special intervention or protection. Taken literally, this provided a green light for 19th century exploitation – the natural world could not be diminished, was in fact forever self-improving, and could be used and consumed ad infinitum.

Darwin also drew no distinction between man and other organisms. As he and many of his peers recognised, this equivalence was one of the most radical aspects of his work. Humans, like any other species, were descended, with modification, from ancient forebears. In defiance of the common view that humans were unique, Darwin argued there was nothing particularly special about humanity's intellectual capacities and needed to recognise itself as simply part of the interrelated natural world along with all other organisms.[14] In *Notebook*

14 Freud in 1917 identified this as one of the three 'great humiliations' of modern society that destabilised the privileged standing of the Enlightenment's 'rational man'. First, according to Freud, came the Copernican Revolution, which decentred Earth's place in the stars. Then came Darwin's model of evolution which removed humanity as the assumed top of the Great Chain of Being and contextualized us as one of many organisms that co-developed within a common ecosystem. Freud claimed his own psychoanalysis later destroyed the illusion that a rational being is always in charge of its own actions (Malazita 2017).

B: Transmutation of Species, he states, "it is absurd to talk of one animal being higher than another. We consider those, where the intellectual faculties most developed as the highest. A bee, doubtless would [use] instincts as a criteria" (Darwin 1837:Paragraph74). Not only was Darwin stating there was a common origin for all beings, but he was also implying there was a common ending: all beings, humans amongst them, were subjected to the same forces and vulnerabilities, including extinction. Yet Darwin famously said little about the implications of natural selection and evolution for humans beyond the ambiguous, "in the distant future…light will be thrown onto the origin of man and history" (Darwin 1859:ChXV). This deliberate omission underscored the importance of the absent message; the silence made by it was louder than any utterance might have been (Chernela 2012). It has been suggested that his theory was a watershed moment in human history, as it marked the point when the possibility of human extinction first began to haunt Western culture (Moynihan 2020).

It is difficult to avoid reading discussions of extinction in Darwin and other 19th century authors in the broader context of Victorian beliefs about competition, racial hierarchy, and imperialism. Prior to Darwin, the colonial powers became increasingly aware of the relationship between their activities and the native inhabitants of their lands and from the 1840s it was common to find discussions on the extinction of so-called 'primitive tribes' in the media (Sepkoski 2020). There was frequent speculation about whether the 'lower races' – judged from a cultural or hereditary perspective – were doomed to inevitable extinction. By the 1850s, this was a well-established trope and questions about the human race and social progress became increasingly entwined within scientific arguments about biology. Upon publication of *Origins* in 1859, Darwin's theory began to be associated with racial extinction, which some thought supported European expansionism. This expansion was underwritten by the belief that it was justified to subjugate and exterminate indigenous peoples because they were doomed anyway by the inexorable logic of biology. If natural selection is the principle that favours individuals best suited to survival and reproduction, then extinction is simply the failure of those who cannot compete, including entire races. Darwin was probably aware of how his ideas would contribute to the discourse on racial extinction, which may help explain his initial reluctance to discuss the implications of his theory for humans. Nevertheless, twelve years after the publication of *Origins*, in 1871, he released *The Descent of Man*, which was an extension of his ideas to include humans. Within this, he made it clear that competition between the races could have a beneficial effect on the human species. By the latter part of the 19th century, it was difficult to find any European naturalists, anthropologists, or explorers who did not think the extinction of indigenous people was an inevitable and unpreventable outcome of European expansion (Moynihan 2020). The potential for human extinction was now established, albeit restricted to particular racial groups at this point.

Many currently view extinction with dismay and even horror, but as discussed above, Darwin saw extinction as ordinary and necessary for progressive evolutionary change

– something that should even be welcomed. So, what explains the transformation in perspective from his time to the present? Have elements of his theory been identified as wrong? Did the growth of scientific knowledge over the proceeding century result in closer attention being paid to extinction? Is there now more widespread extinction that we recognise as potentially threatening our own existence? Did global events over the course of the 20th century impact our perceptions of the natural world and our relationship with it? The answer to all these questions is yes, and they are just some of the explanations why the thinking about extinction is where it is today.

The rest of this chapter will track the cluster of reasons for the changed perception of extinction in the present. The reasons will show how scientific developments, ideological changes, and global events dramatically reshaped the concept over the course of the 20th century. This includes the gradual re-emergence of catastrophic thinking about the Earth's deep past, the atomic age, greater understanding of Earth System processes stimulated by Cold War military research, increasing empirical evidence of mass extinctions, and the recognition of diversity as an essential biological and cultural resource.

2.6 THE GRADUAL RE-EMERGENCE OF CATASTROPHISM

Palaeontologist David Raup has observed that following the publication of *Origins* in 1859 by Darwin, extinction largely dropped out of the consciousness of most evolutionary biologists and palaeontologists until the latter decades of the 20th century (Raup 1994). Only with the controversy in the 1980s over the causes of the end-Cretaceous extinction episode that destroyed the dinosaurs and the development of concerns for presently endangered species was the role of extinction confronted in what he calls 'modern' terms. The modern terms he refers to involved treating extinction as a significant biological phenomenon that could be thought about independently of ordinary evolutionary processes. Recall that for Darwin, extinction and speciation were flip sides of an integrated whole – natural selection – that couldn't be separated. This idea remained the received wisdom until the 1980s and there was strong resistance to treating them separately (Sepkoski 2012). Also, as has been noted, the discrediting of Cuverian catastrophism by Lyell in the 1830s made it difficult to even legitimately research mass extinctions until the 1960s when the term slowly began to be reclaimed by scientists. Until this point, proponents of catastrophe and sudden mass extinctions were consistently regarded as "lunatics" (Benton 2015:Ch4) and were derided for their heterodox views.

From 1859 to the early 1960s, there was little mainstream research about extinction with almost no published scientific material (Bambach 2006). Beginning in the late 1950s, though, the biological understanding of it began to undergo a slow but ultimately profound transformation that decades later saw the catastrophic model of mass extinction accepted as the best explanation for the major changes in life's past. This commenced with the work of Otto Schindewolf, who brought the first modern version of catastrophism into play in 1958 when he proposed that bursts of cosmic radiation, possibly from supernovae, might be the cause of the great faunal changes over deep history He was ridiculed for his far-out idea at the time and to the present, no independent evidence for cosmic rays has been discovered (Benton 2015).

In the 1960s, palaeontologist Norman Newell became the central figure in codifying the idea that the history of life had been punctuated by a series of mass extinctions through a succession of papers he produced on the "crises in the history of life" (e.g., Newell 1963). He compiled what at the time was the most comprehensive fossil dataset of marine invertebrates and advanced several arguments for the possible causes and timings of global extinctions, including changes in atmospheric oxygen, disease, cosmic radiation, trace-element poisoning, climatic changes, and violent upheavals of the Earth's crust. The explanation he favoured most, however, was fluctuations of sea levels. The high rates of extinction at the close of a geologic era, period, or epoch were, he believed, readily explainable by the withdrawal of the epicontinental seas from the continents. This change in environment, he thought, was the only one capable of producing mass extinctions of marine genera on a global scale. Newell's ideas here mark an important turning point in the study of extinction. Whilst previously much attention had been given to the spectacular disappearance of vertebrate groups such as the dinosaurs or large mammals like mammoths or mastodons, from this moment on the problem of mass extinctions would centre on marine invertebrates such as trilobites and molluscs. This was not because scientists had lost interest in the dinosaur extinctions – far from it – but rather that the source of the data, marine invertebrate fossils, which have been preserved in quantities many orders of magnitude greater than vertebrate remains, offered a much better statistical sample to base theoretical ideas. Another novel aspect of Newell's work was though he was effectively proposing catastrophic explanations for the mass disappearance of species in the past, unlike Cuvier, he believed they were gradual, not sudden, violent cataclysms. This was effectively the merging of both Cuvier and Lyell's ideas – catastrophe is a regular feature in the history of life, Newell was implying, but it occurs over geologic timescales, rather than instantaneously, as Cuvier believed. Newell, though, was careful about reprising historical debates about extinction by not describing such events in Cuverian language. A term like "catastrophism is a term with emotional connotation that implies calamity and destruction," he argued, "and as such, it is not appropriate in any scientific context" (Newell 1967:66).

From the middle of the 1960s then, as scientific ideas about extinction began to develop, we begin to see the recognition that mass extinctions may have been a feature of the history of life and that the Darwinian model of gradual, repetitive replacement was inadequate to explain certain phenomena in the fossil record. We also begin to see a recognition that the key to understanding the causes of past extinctions – and potentially predicting the causes and consequences of future ones – lay in understanding ecological interdependencies. The roots of this understanding can at least in part be traced to the beginning of the atomic age in 1945 and the ensuing research that transformed our understanding of the planet and its processes.

The detonations of the nuclear bombs over Hiroshima and Nagasaki in 1945 at the end of the Second World War and the commencement of the Cold War in the late 1940s helped turn the world into an experimental laboratory that transformed the globe and the direction of scientific research (Masco 2010). The earth sciences became a US national priority as efforts to study the bomb's material effects connected researchers to the Department of Defence in a new way, leading to revolutions in computing, geology, oceanography, and atmospheric sciences (Masco 2015). This resulted in a powerful new vision of the biosphere as an integrated ecological space of complex interactions, undermining the logic of the national security state with the linkage to discrete territories and populations. It also facilitated a new understanding of catastrophic risk that permeated the public realm. Nuclear war was recognised as a major threat to the planet's biological support system and instilled the idea that the total destruction of humanity was just a button push away.[15]

The satellite technologies of the Cold War, then, led to a new understanding of the interconnectedness of life and an increase in awareness of terms such as ecosystem and the biosphere. The importance of species diversity as a storehouse of variability was also increasingly appreciated,[16] and ecologists began to theorise the relationship between species numbers and stability. Recall that Darwin and indeed other 19th century biologists believed that nature was in a state of natural balance and inherently regulated itself. By Darwin's logic, natural selection ensured that the Earth was always populated by a relatively stable diversity of species since the zero-sum principle of competitive replacement meant that species were fighting for a finite number of environmental resources. As the 20th century progressed, ecologists questioned these ideas and began to see that there could actually be instability within the system and that humans could be the agents of it.

Concerns about an environmental crisis were also increasingly emerging, driven decisively by Rachel Carson's hugely popular 1962 book *Silent Spring*, which warned of a disaster in progress. Readers were left with the idea they were living in a poisoned world, one in which the air, waters, and soils were becoming toxic and unnatural, and where death literally rained down from the sky in the form of pesticides. Paul Ehrlich's multi-million-selling *Population Bomb* reprised 19th century Malthusian ideas around catastrophe, raising the possibility of human extinction through planetary overpopulation. In the book's opening pages, he starkly declares, "The birth rate must be brought into balance with the death rate or

15 Environmental historian Jacob Hamblin has shown that the US government did not limit its Cold War program of risk assessment to nuclear war. A whole host of environmental catastrophes were also modelled, including climate change, crop failure, and overpopulation. It was identified that some of these outcomes might be deliberately triggered as part of US military strategy. Hamblin argues these projections were a key factor in the birth of 20th century environmentalism (Hamblin 2013).

16 Sepkoski (2020) argues this is one of the 20th century's most important and unexamined cultural notions. That is, any complex collection of biological entities whether genetic population, an ecological system, or a human society is made stronger and more resilient to change by having variability. Diversity, therefore, came to be conceived as an inherent property of healthy collectives with intrinsic positive value.

mankind will breed itself into oblivion" (Ehrlich 1968:xi). One of the key elements of his argument was the focus on the dynamics of ecological systems. Ehrlich argued that the simple systems were the most unstable and human overpopulation and colonisation of the planet agriculture had resulted in humans simplifying ecosystems calling into question their long-term survival. At the beginning of the 1970s, US senator and prominent environmentalist Gaylord Nelson, originator of the idea of the first Earth Day in 1970, argued the environmental crisis "was the most critical issue facing mankind…Vietnam, nuclear war, hunger, decaying cities, and all other major problems one could name are relatively insignificant by comparison" (Gaylord Nelson 1970, as cited in Buell 2003:viii).

So as the latter decades of the 20th century began, there was growing acceptance by scientists that catastrophe may have played an important role in shaping the history of life. After more than a century of being discredited, improved fossil databases and new theories were beginning to emerge that permitted scientists to speculate with any credibility that the Earth's deep past may have been punctuated by catastrophe. At the same time, there was an increasing awareness of the harmful effects human activities were having upon the biosphere and the risks this posed to their own existence. This broadly stemmed from a new understanding of ecological interdependencies and the interconnectedness of life, the recognition that humans could impact the stability and balance of nature, an appreciation of diversity as a storehouse of both variability and resilience, and a reprisal of Malthusian ideas about population dynamics. The emergence of this new scientific knowledge was taking place during the Cold War and some of it was stimulated by US military research modelling the threats to the environment posed by nuclear war. Also, since the late 1940s when the Soviet and Western blocs began the arms race, human societies had been living under the spectre of complete annihilation by the bomb. A sense of pessimism about the future was growing and there was a recognition that at any moment there could be nuclear conflict.

In more or less the same time period, therefore, we see the above issues coalescing and feeding into each other. Added to this over the following two decades would be the concrete proof that catastrophic mass extinctions were a regular feature of Earth history and increasing concerns that humans may be driving another one.

2.7 THE NEW CATASTROPHISM

As the 1970s progressed, there was a growing awareness of human-caused species extinctions and conservation advocates began to realise the effectiveness of comparisons of current species loss with episodes of elevated extinction in life's past. Ehrenfeld (1972), for example, argued that the current rate of extinction of most mammals was approximately a thousand times higher than in the late Quaternary, a geological period distinguished by high extinction rates.[17] In a

17 As discussed in chapter 1, the late Quaternary period was a time when two-thirds of all global mammalian megafauna (animals above 44kg) became extinct everywhere except in Africa (Martin 2007).

widely popular book, *The Sinking Ark*, Myers (1979) provided an even more dramatic estimate, arguing that the proceeding twenty-five years could see the extinction rate grow to forty thousand species a year which may eventually amount to a biological calamity greater than all the extinctions in the past put together.

At the same time, palaeontologists were increasingly querying whether the fossil record could really be explained by Darwin's theory of evolution by natural selection. In a letter between palaeontologists Raup and Schopf in 1979, Raup commented, "I am becoming more convinced that the key gap in our thinking for the last 125 years is the nature of extinction" (Raup 1979, as cited in Sepkoski 2020:Ch5). His letter went on to explain,

> If we take neo-Darwinian theory at face value, the fossil record makes no sense. That is, if we have a) adaptation through natural selection and/or species selection and b) extinction through competitive replacement or displacement, then we ought to see a variety of features in the fossil record that we do not such as: a) clear evidence of progress, b) decrease in evolutionary rates (both morphologic and taxonomic), c) probably a decrease in diversity.

Raup was arguing that Darwin's reasoning about natural selection was not borne out by the fossil evidence. Darwin had assumed that Lyell's steady-state uniformitarian model of geology, where the surface of the Earth changes slowly over vast timescales, also governed the history of life as well. Not only had recent analyses of the fossil record showed species numbers had continually increased over time (disproving Darwin's key idea that speciation and extinction were in balance), but it also suggested extinctions didn't always operate according to the selection rules Darwin had proposed. Raup, within the same letter to Schopf, put it like this,

> The neo-Darwinian system is at work all the time – producing trilobite eyes and pterosaur flight – but never really gets anywhere in the long run because the trilobites and pterosaurs get bumped off (through no fault of their own!)…The system is always heading toward a steady state but never gets there.

In other words, progressive evolution was all well and good, but it ultimately took species nowhere because they were "bumped off" by external events. The events he was referring to would soon be confirmed once and for all as mass extinctions.

The research by palaeontologists such as Raup in the 1970s coincided with the discovery by experimental physicist Luis Alvarez and his geologist son, Walter Alvarez, that the dinosaurs had perished in a fiery cataclysm 66 million years ago. In 1978, during a search to understand the extinctions, they discovered unusually high levels of iridium deposits in well-preserved sections of the Cretaceous-Palaeogene boundary in Gubbio, Italy, at the precise location where the dinosaurs disappeared from the fossil record. Iridium is a very rare chemical element in the Earth's crust but is abundant in meteorites. The Alvarez team took the presence of the metal as evidence that the impact of a massive meteorite led to the death of the dinosaurs. They spent two years analysing their findings and eventually released their results in a paper in *Science*, "Extraterrestrial Cause for the Cretaceous-Tertiary Extinction" (Alvarez et al. 1980). The article provided what was eventually accepted as conclusive evidence that the dinosaurs were killed by a cataclysmic event.[18] It was also the first proof of what Cuvier had speculated on at the start of the 19th century in his *Essay on the Theory of the Earth* that there had been mass extinctions in the Earth's deep past. The discovery, still commonly referred to as the "Alvarez hypothesis", contributed to the acceptance of catastrophe as a common characteristic of planetary history. It also negated the hard-core uniformitarian conceptions of the Earth's past of slow and uneventful change that had prevailed since the 1830s, thus "cracking the framework of Lyell and Darwin" (Kolbert 2014:Ch5).

Alvarez's hypothesis caused a sensation in its day both publicly and scientifically, and over the decade that followed debates raged across the pages of academic journals and the popular media. *The New York Times* infamously ran an editorial in 1985 chiding those investigating extra-terrestrial causes for mass extinctions with the rebuke that, "astronomers should leave to astrologers the task of seeking the causes of earthly events in the stars" (New York Times 1985). Stephen Jay Gould later called this "one of the most disturbing and anti-intellectual statements I've read in years" (Gould 1985, as cited in Sepkoski 2012:342). In mainstream academic journals, there was a pronounced split: in *Science*, the coverage supporting Alvarez's idea was overwhelmingly positive. In *Nature*, it was almost completely negative. However, in time, the idea came to be broadly accepted and to the present, an asteroid impact remains the main causal explanation for the disappearance of the dinosaurs (Chiarenza 2020).

The importance of Alvarez's discovery and the subsequent formal recognition of mass extinctions as major features of Earth history cannot be over-emphasised. It has been described as one of the most important scientific discoveries of the 20th century (Leaky and Lewin 1995). It transformed 120 years of Darwinian evolutionary theory, which claimed that species disappeared through inherent genetic deficiencies, exposed by their competition with other species over finite resources. What had been speculated on for years without any definitive evidence had been finally proved – species can disappear for non-evolutionary reasons, specifically because of catastrophic forces such as a giant asteroid. This led to a new understanding of both macroevolution and the longer history of life. Without mass extinctions, there would still be 'progressive' species evolution (a key Darwinian concept)

18 The location of the impact was not discovered until 1991. The asteroid was eventually named, Chicxulub, the Ancient Mayan word meaning "tail of the devil". For a detailed history of the development of the Alvarez hypothesis from its first proposal to its eventual acceptance by the scientific community, see Alvarez, Walter. 2015. *T. Rex and the Crater of Doom*. 2nd ed. Princeton University Press.

IMAGE 2.8 Cover of Time magazine, May 6th, 1985
Source: Time magazine (2021)
A sample of the popular media coverage following the Alvarez hypothesis.

but without any major branching. Only mass extinctions and the devastation they caused cleared ecological space for the radiation of new lineages, such as the expansion of mammals following the disappearance of the dinosaurs, and as such they are now recognised as defining events in the evolution of complex life. It should be emphasised that the re-emergence of catastrophism was not a simple reprisal of the Cuverian idea that species turnover was caused *only* by catastrophe. Instead, this "new catastrophism"[19] recognised both periods of stability (with steady rates of background extinction via the process of natural selection) punctuated by major crises that have totally reset the ecological and environmental conditions of the planet: in short, a combination of Cuvier and Darwin's separate but related ideas.

Research for the "Alvarez hypothesis" involved computer modelling of the post-asteroid impact atmospheric pollution and the effects it had on weather patterns and photosynthesis. This caught the attention of American nuclear scientists who, at the time, were still considering the impacts a nuclear war might have upon the global atmosphere. In the 1980s, they started a major international research program, headed up by Carl Sagan, devoted to what they called the "nuclear winter hypothesis" (Masco 2010:18), to model the consequences of nuclear war. Using the same computer model and team of experts used by Alvarez (who coincidentally had also worked on the Manhattan Project[20] atomic tests in New Mexico during the 1940s)

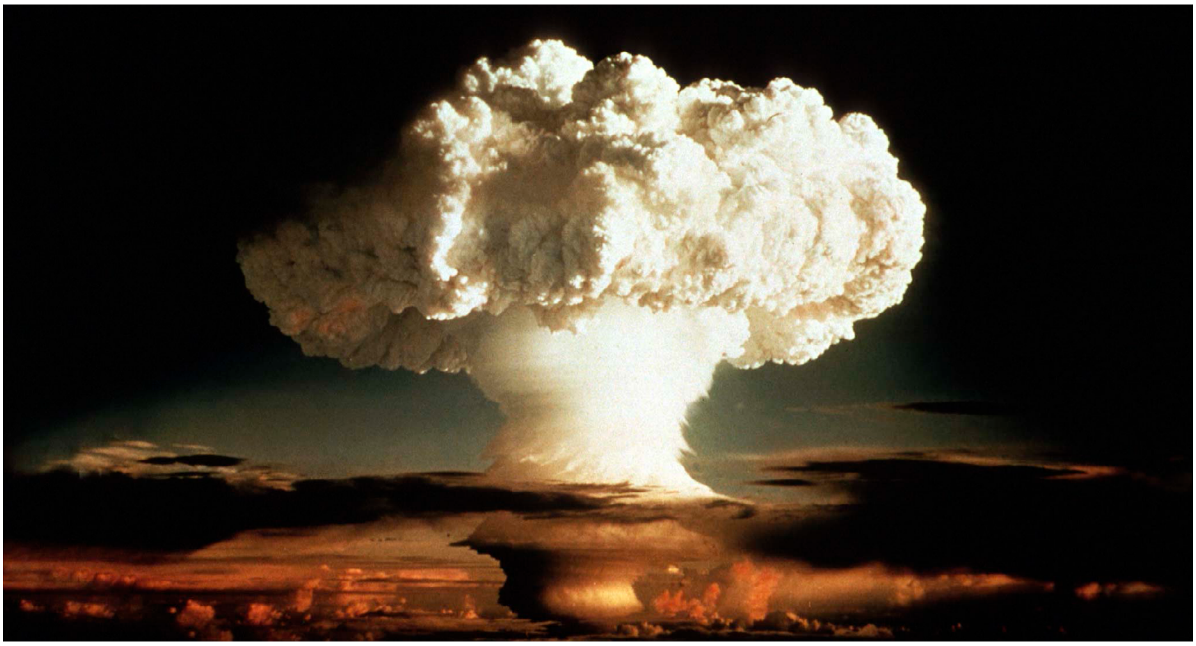


IMAGE 2.9 Castle Bravo – the largest ever US nuclear explosion in 1954
Source: Brookings Institution (2021)
What would the days, weeks, and years after a thermonuclear explosion really look like? In 1983, Carl Sagan and his team gave the public their first imagining.

19 German palaeontologist, Otto Schindewolf, first came up with the term 'new catastrophism' in 1963 based upon his research of what was later designated the end-Permian mass extinction (Benton 2015).

20 The Manhattan Project was a research and development undertaking during World War II that produced the first nuclear weapons. It was led by the United States with the support of the United Kingdom and Canada.

they subsequently published two papers on the nuclear winter scenario (Turco 1983; Ehrlich 1984) that received widespread attention.[21] The nuclear winter was presented as analogous to recent discoveries about the major mass extinctions in life's past and the public connected them with each other (Sepkoski 2020). The close association between the extinction of the dinosaurs and the potential extinction of humans through nuclear war were linked both scientifically and psychologically. In the 1980s, humans began to dwell increasingly within the concept of extinction and the stage was set for the proposition of the sixth mass extinction of species. This would emerge within the next decade and would be seen as coterminous with the possible extinction of humans.

2.8 THE BIODIVERSITY MOVEMENT AND THE SIXTH EXTINCTION

By the mid-1980s, concerns around species loss were developing rapidly and in 1986 the American National Academy of Sciences, along with biologist E.O. Wilson and physiologist W.G Rosen, organised the National Forum on Biodiversity. The event attracted hundreds of scientists, policymakers, and journalists and involved over sixty speakers discussing the causes and consequences of human-caused extinctions of animal and plant species. This was the first time the term "biodiversity" had ever been used, and it gained significant traction thereafter. It had no formal definition at this point and was largely used as a synonym for species richness, something that continues to this day. There is still no agreed operational definition and, in fact, ten years after its first inception, there were at least twenty-three different formulations (Takacs 1996).

The National Forum and the wide publicity it received contributed to the emergence of the biodiversity movement, a branch of environmentalism focussed primarily on concerns about species loss. Whilst biodiversity awareness burst onto the scene suddenly and with rapid success during the 1980s, as described, popular and scientific discussions on the impacts of humans on the natural world had begun to emerge during the 1960s. As historian Timothy Farnham states, "The rise of popularity of the biological diversity cause [during the 1980s] was not necessarily a paradigm shift, but it was a confluence of values and concerns fostered over time" (Farnham 2007:12). Though ecologists and conservationists had expressed concern for the fate of endangered species for decades, palaeontological perspectives on mass extinctions during the 1980s shifted the focus to the potential loss of entire ecosystems and the protection of biodiversity as a whole. Palaeontologists such as Jablonski (1991) were also amongst the first to make explicit the connection between present-day species loss and the mass extinctions of the distant past.

The 1980s also saw the emergence of the discipline of Conservation Biology as a "new stage in the application of science to conservation problems…to provide principles and tools

21 Sagan was invited to debate nuclear winter before Congress in 1984. In 1988, he was mentioned by Soviet Premier, Mikhail Gorbachev, in his meeting with Reagan as a major influence on ending proliferation.

for preserving biological diversity" (Soulé 1985:727). Considered a 'crisis discipline' from the onset, conservation biologists were expected to act before knowing all the facts about the conservation issues they were facing. That is, to make decisions or recommendations about the design and management of projects before they were fully comfortable with the theoretical and empirical basis of the analysis. Tolerating uncertainty was an inherent aspect of dealing with the urgency of the age (Kareiva 2012).

In 1992, E.O. Wilson published *The Diversity of Life*, which was the first speculation that a new mass extinction of species was occurring. He stated, "Humanity has initiated the sixth great extinction spasm, rushing to eternity a large fraction of our fellow species in a single generation" (Wilson 1992:Ch3). His proposition was derived from his research on the loss of the world's tropical forests, half of which had disappeared between 1950 and 1990 (Buell 2003). Within it, he tied biodiversity loss, and the ecosystem services they provide, to the future fate of humanity, "Without these amenities, the remaining tenure of the human race would be nasty and brief…We will have become like the pilot whales that inexplicably beach themselves on New England shores" (Wilson 1992:Ch15).

It is worth pausing momentarily to reflect that at this point, there were now three different conceptions of extinction in operation. First, there was the recognition that human activities were driving the extinction of other species, with the endangered species of the IUCN Red List officially evidencing our destructive power (the first formulation of the list was in 1991). Second, these extinctions were pushing us into another mass extinction and humans were witnesses to it. Third, this "sixth" extinction placed the longer-term future of humanity in doubt, triggered by a collapse of the planet's biological and ecological systems. Awareness of these different but wholly related conceptions of extinction all happened during a brief period in the latter decades of the 20th century, though as we have discussed, they were a consequence of a longer series of events stretching back two hundred years. Each of these, in turn, we might say drove an increased level of anxiety about the future.

In the same year that Wilson's pivotal book was released, the Union of Concerned Scientists also issued a "Warning to Humanity", supported by 104 Nobel laureates among the more than 1700 scientists endorsing it. The authors feared that humanity was pushing the Earth's ecosystems beyond their capacities to support the web of life. They described how we are fast approaching many of the limits of what the biosphere can tolerate without substantial and irreversible harm. They stated,

> Human beings and the natural world are on a collision course. Human activities inflict harsh and often irreversible damage on the environment and on critical resources. If not checked, many of our current practices put at serious risk the future that we wish for human society and the plant and animal kingdoms and may so alter the living world that it will be unable to sustain life in the manner that we know (Union of Concerned Scientists 1992).

Also in 1992, as one of the outputs of the Rio Earth Summit,[22] the UN opened for signature the *Convention on Biological Diversity* (CBD).[23] This was an international legal instrument, centred around the conservation of biodiversity, that reflected growing scientific and public concerns about the diminution of the world's "genetic resources". Though there had been a Convention on International Trade in Endangered Species (CITES) in operation since the 1970s in response to threats to traded species, the CDB was created to address the use of and threats to biodiversity more widely, including development. It was the first major treaty that attempted to protect not only species but the natural environments and ecosystems they were part of.

There were a variety of outputs in the 1990s, therefore, that consolidated the idea that the future of human society and potentially humans themselves was inextricably bound up with the conservation or loss of biodiversity. It could reasonably be argued that extinction at this point had become a crystallising concept, bringing together broader environmental concerns under the same rubric. It unified not just concerns about species loss but also anxieties about the drivers of the losses, including deforestation, pollution, and over-exploitation. Serious concerns about climate change were also beginning to emerge. In 1990, the IPCC had released their first assessment report that included dire projections about global temperature increases during the 21st century.[24] At the Earth Summit in Rio in 1992, the *United Nations Framework Convention on Climate Change* (UNFCC) was also introduced, which eventually led to the Kyoto Protocol.

As the latter decade of the 20th century progressed, therefore, dystopian fears about sudden nuclear annihilation and overpopulation had been supplanted by a new set of anxieties about climate change and the sixth extinction. Both these issues tied the environmental crisis to the deeper history of the Earth and the scales and rhythms of geological time. With the threat of nuclear war receding, Earth System science and the myriad of surveillance technologies developed during the Cold War now focused their attention on the human transformation of the biosphere. This led to the recognition that not only were humans causing an environmental crisis, but in their scale and influence, they were becoming

22 The United Nations Conference on Environment and Development (UNCED), also known as the Earth Summit, was a major United Nations conference held in Rio de Janeiro from June 3rd to June 14th, 1992. The summit was created as a request for member states to cooperate internationally on development issues after the Cold War.

23 *The Convention on Biological Diversity*, known informally as the Biodiversity Convention, is a multilateral treaty that has been ratified by 196 nations. The convention has three main goals: the conservation of biological diversity; the sustainable use of its components; and the fair and equitable sharing of benefits arising from genetic resources.

24 Perhaps surprisingly there was no real discussion about the potential impacts of climate change upon biodiversity and in fact, the first assessment was sanguine about species loss, stating, "Because species respond differently to climate change some will increase in abundance and/or range while others will decrease…Some species may be displaced to higher latitudes and altitudes and may be more prone to local and possibly even global extinction and others may thrive" (IPCC 1990:XXX).

geological agents. Their activities were now rivalling some of the great forces of nature in the Earth's past, including the dinosaur-killing asteroid. The Anthropocene epoch had arrived.

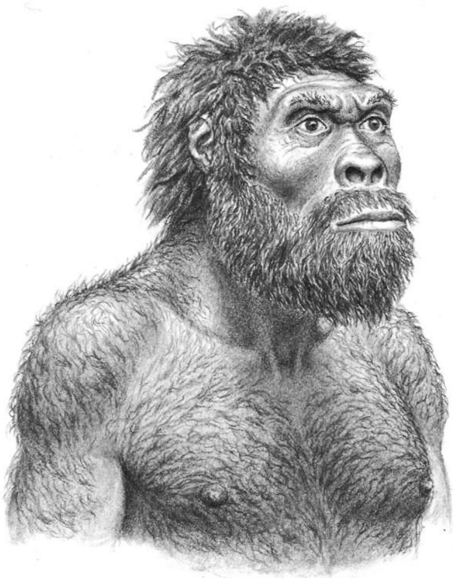
2.9 CONCLUSION

Over the course of two centuries, from the first 'discovery' of extinction by Cuvier in 1796 to the declaration by Wilson in 1992 that humanity had initiated the sixth extinction, conceptions around the disappearance of species have changed dramatically. Extinction has been transformed from being denied, to being accepted, to being welcomed, to where we are today, as something that is feared. Though each of these transformations was to a lesser or greater extent driven by changing scientific ideas about extinction (in their day often a source of major disagreement), these ideas themselves were influenced by a variety of other factors including religious beliefs, parallel scientific developments such as the discovery of deep time, Cold War geopolitical tensions, changing perceptions of the natural world, and existential anxieties. These factors, and no doubt many others, coalesced and buffeted each other over time and, I contend, contributed to the proposition of the sixth extinction where the fate of species and humans was seen as conterminous.

It is apparent from the contents of this chapter that extinction is not simply an issue of science but also one of ideology, history, and culture which have repeatedly fed into each other, "remaking" conceptions of extinction over time. It has meant different things at different points of its history, a phenomenon Sepkoski (2020:Introduction) has termed the "extinction imaginary", something he defines as "the complex set of beliefs associated with extinction at any given historical period". We see this repeatedly throughout the brief history I have sketched above. For example, Cuvier's "catastrophism", the first theory of extinction in 1813, that speculated the Earth was a succession of former worlds truncated by major catastrophes in the deep past, was ridiculed in its day. His theory was dismissed as unscientific, in part because he tried to accommodate religion within his ideas but also because his proposition was inimical to Victorian ideas of order and progress within nature. Thereafter, for well over a century, those researching major geophysical events in the Earth's past, including the occurrence of mass extinctions, were considered charlatans, heterodox, and even lunatics. However, in the 1980s, following the broad recognition that the extinction of the dinosaurs was caused by a giant asteroid hitting the Earth, some of his ideas came to be accepted. Cuvier had in part been vindicated – the history of the planet was punctuated by catastrophe and life did indeed periodically change course. Thereafter, following a 150-year hiatus, mass extinctions became popular objects of study.

Scientific theories of extinction are closely bound up with the cultural concerns of any given period. They also, tacitly or otherwise, include prophecies about the future direction of life and human societies. With this in mind, what does the 'extinction imaginary' of the current moment, here in 2022, tell us about our hopes and fears for humans and the natural world? Are we living in a continuation of late 20th century anxieties about biodiversity depletion, a new mass extinction, the collapse of human societies, and the potential for self-extinction? Or with growing awareness of the anthropogenic impacts upon Earth System processes, including cascading climate change, have we entered another, even more extreme phase? The next chapter will explore these and other questions, positioned within the emerging discourse of the Anthropocene. I will propose that the catastrophic prognostications of the Anthropocene exacerbate the fears of ecological collapse implicit within the proposition of the sixth extinction, giving it a greater sense of imminence. It also, by extension, amplifies the concerns humans have about the possibility of their own demise.

In chapter 1, I identified that owing to a lack of information, it is currently impossible to determine whether we're in or entering a human-made sixth mass extinction of species. However, I will argue that irrespective of this, we do seem to be running into an ontological death. Extensive biodiversity loss (WWF 2020), evidence that climatic tipping points may already have been crossed (Lenton 2019), and significant alteration of some of the Earth's biogeochemical cycles (Steffen 2011), amongst other things, are alerting us to the possibility that humanity may have locked itself into a 'bad set of futures' (Ord 2020) that on timescales meaningful for the human species we may be unable to escape from. Not only does this constitute a crisis for many of the planet's life forms, but also, I will argue, a crisis of modernity and the dominant conceptions of the world.



CHAPTER 3

ECOLOGICAL VULNERABILITY AS ONTOLOGICAL VULNERABILITY

> When you were mocking other people because they "naively believed" that the sky could fall on their heads, you now realise that *you too* are convinced that the sky will fall on your head. (Latour 2011:6)

> Clearly, planet Earth has not exploded. But the concept *world* is no longer operational. (Morton 2013:6)

> The end of the world as we know it is not the end of the world full stop. (Kingsnorth and Hine 2009:19)

3.1 INTRODUCTION

In chapter 1, I reviewed the scientific data exploring the proposal of a human-caused sixth mass extinction of species. As described, there are significant information deficiencies that presently make it difficult, if not impossible, to ascertain the scale of the current extinction episode, calling into question the veracity of such a grand claim. Despite this, the sixth extinction idea has gained significant traction across a variety of realms. Along with climate change, it is often considered emblematic of the destructive impacts of human activities upon the natural world.

Yet if the surrounding science is patchy and inconclusive, as I showed, what explains the widespread belief in and popularity of such a profound idea? In chapter 2, I examined this. By tracing two centuries of thinking about extinction, from the initial discovery of species disappearances in 1796 to the first proposition of the sixth extinction in the early 1990s, I identified that perceptions of extinction have consistently and dramatically transformed over time. Though these transformations have largely been driven by scientific developments, including Darwin's theory of evolution and the discovery of geological mass extinctions, other factors have also influenced them. This includes religious beliefs, global events such as the Cold War, growing awareness of human degradation of the natural world, and existential anxieties about the future of humanity.

These influences, and doubtless many others, coalesced and buffeted each other over time and, I argued, contributed to the proposition of the sixth extinction. This led me to propose that from the onset the idea has been a crystallising concept extending beyond concerns about species loss. It has brought together some of the broader fears about the state of the planet, including issues such as habitat loss, over-exploitation, and pollution – all drivers of extinction and environmental problems in their own right (Cafaro 2015). It also helped to establish the idea that the fate of humans and other species are connected – biodiversity loss, if left unconstrained, might result in societal collapse and perhaps the disappearance of humans altogether.

If the possibility of a sixth extinction tied the fates of humans and other biological life together, the proposition of the Anthropocene in 2000 by atmospheric chemist Paul Crutzen and limnologist Eugene Stoermer took concerns about the state of the planet to a whole new level. The realisation that the cumulative effects of human activities are impacting the systems, geology, and ecologies of the entire planet brought a stark recognition that Earth and human histories have become entangled so that "the fate of one determines the fate of the other" (Zalasiewicz 2010:2231). Though humans overall never been more potent nor exercised such domination over nature, we are also, it is claimed, simultaneously vulnerable to the power of nature and the vicissitudes of the Earth in a way we have not known for 12,000 years with the retreat of the last great ice sheets (Hamilton 2017). Humans have been able to take for granted the stable background conditions of the ecological niche in which our species evolved and thrived on the planet. However, the cumulative impacts of our activities, particularly over the past 250 years or so with the arrival of industrial modernity, are beginning to unravel them, placing our longer-term survival in doubt.

With this in mind, what do the claims of the Anthropocene do to the "extinction imaginary"[1] of the present? Are we still living in a continuation of 1990s anxieties about biodiversity depletion and the potential collapse of human societies, as described in the previous chapter, or have we entered a new phase? The catastrophic prognostications of the Anthropocene, including the startling claim that humans have now become geological agents on par with the great forces of nature (Steffen 2007), make us aware of the sheer scale and depth of the human imprint upon the planet. This, I contend, exacerbates the fear of ecological collapse implicit within the idea of the sixth extinction, giving it a greater sense of imminence and fatalism. Regardless of whether one sees the current situation as redeemable, there is a common perception that the environmental crisis is already upon us and not left to the imagination of some future catastrophic events. By extension, this amplifies the concerns humans have about the proximity of their own demise.

For those who are pessimistic about the future, the implications of the Anthropocene seem straightforward: humanity will die. Yet we cannot assume the death we are facing will be simply biological death or extinction. Whether or not we are running into a mass

1 As discussed in chapter 2, this is defined as "the complex set of beliefs associated with extinction at any given historical period" (Sepkoski 2020:Introduction).

extinction and a biological demise, we in the West[2] at least do seem to be facing an ontological[3] death. Extensive biodiversity loss, evidence that climatic tipping points may already have been crossed, and significant alteration of some of the Earth's biogeochemical cycles, amongst other issues, are alerting us to the possibility that humanity may have locked itself into a 'bad' set of environmental conditions that on timescales meaningful for the human species we may be unable to escape from. The way of life for many of the planet's inhabitants is becoming increasingly precarious and is likely to remain so indefinitely as the Anthropocene plays itself out into the future. As Tsing (2015:Ch1) observes, precarity is no longer only the fate of the less fortunate. It is now "the condition of our time".

The awareness of this, and that the shifts that are occurring can, historically at least, be laid at the feet of a few "blood, carbon, and capital-soaked nations" and their particular ways of being in the world (Flores 2016:128) "smashes" and "disperses" the key structures of modern thought and life (Latour 2016:Ch12). LeCain (2016) has described this as the 'Great Ontological Collapse' – the realisation that the guiding 'modernist' principles shaping Western thought and action over the past few hundred years are incompatible with the realities of the world. This includes the age-old belief that humans are somehow emancipated from nature, existing on a plane above the base material world around them. It also marks an end to the expectation of continual progress and eternal human flourishing – another key tenet of the modernist worldview.

In consideration of the above, this chapter will investigate the idea that the sixth extinction proposition and the broader ecological concerns about the state of the planet as they manifest within the Anthropocene discourse can simultaneously be interpreted as an expression of ontological concerns about the collapse of the 'modern way of life'. Or, to phrase things differently, the collapse of the 'modern world'. Whilst it is difficult to argue that the environmental situation humanity finds itself immersed within is not a crisis of nature, as Buell (2003) suggests, for humans, it is also, and perhaps mostly, a crisis of society. These separate but related crises result in what Lear (2006) in another context has described as 'ontological vulnerability'. Confronted with the possibility of the sixth extinction and the arrival of the Anthropocene, our ecological vulnerability ushers in our ontological vulnerability.

I begin the discussion by providing an overview of the Anthropocene concept, explaining why it is so significant and not simply an extension of 20th-century environmental concerns about the state of the planet. I will summarise the key definitions, claims, and narratives, describing how its arrival is perceived by many as a time of rupture, registering environmental shifts not seen for millions of years, and heightened human vulnerability in the face of an increasingly hostile Earth.

2 See McNeill, William H. 1997. "What We Mean by the West." *Orbis* 41 (4): 513–24.

3 For the purposes here, I adopt the idea that ontology reflects the variable sets of historically contingent assumptions through which humans apprehend reality. This position makes ontology effectively synonymous with culture. See Carrithers, Michael, et al. 2010. "Ontology Is Just Another Word for Culture." *Critique of Anthropology* 30 (2): 152–200.

I will next probe this vulnerability by investigating the risk of human self-extinction. Omnicide would seem to be implicit within the sixth extinction proposition and the apocalyptic, eschatological tone of the Anthropocene discourse, which invariably stresses the inevitability of social and ecological collapse driven by human activities. This reveals that whilst the biological disappearance of *Homo sapiens* is a genuine possibility over the next century, it is considered far more likely humans will endure into the longer future. This will lead me to query what is meant by the term 'extinction' as it pertains to humans. I identify that even though there is typically little confusion about what the extinction of other species means (human-induced or not), fears about human extinction cannot simply be interpreted as the discontinuation of humans as biological entities. Extinction also, and perhaps mostly, seems to mean extinction ontologically.

This provides a platform to discuss how the arrival of the sixth extinction and the Anthropocene are thought to constitute a crisis of a particular set of world-making beliefs and practices, commonly known as 'modernity'. The threat to modernity, as I will explain, is given equivalence with the 'end of the world'. Concerns about this are also tightly bound up with an inability or unwillingness to imagine that the end of the world might not be the actual end and that there is a possibility of another world to come. This, I suggest, helps explain the sense of urgency within the current extinction imaginary about saving, rather than transforming, the existing world.

I will next explore some of the ontological and political complexities of the Anthropocene and the 'end of world' narratives. Commencing with a reflection on the notion of world itself and whether we live in a 'one-world world' (Law 2015), or a 'pluriverse' (Escobar 2016), I ponder the subject position of the world deemed under threat. Is the whole of humanity heading towards its 'end times' (Žižek 2011), or just a particular part of it? This will also prompt me to discuss how the overexposing rhetoric about the 'end of the world' conceals the fact the world now envisaging its end was only possible in the first place because it erased so many other ones. It also required that many continue to exist in a world already ended, in a life of 'social death' (Colebrook 2020). This is exemplified by the many indigenous people of the planet who have lived through countless apocalypses brought about by European colonialism and its repercussions.

Finally, I explain how the flattening of humanity into 'Anthropos' occludes the different relationships humans have with the environmental crisis. This is in terms of historical responsibility for it and how the impacts have and will be felt over time. I will note, though, that the situation is increasingly blurred as the line between victims and perpetrators, regionally at least, becomes less clear over time as the Global South copies the northern industrial model of environmental harm in the pursuit of poverty-alleviation and affluence.

I conclude by observing that ontological vulnerability and the successive disappearance of worlds are part and parcel of humanity's historical way of being. The end of a world – any world – does not prevent the possibility of another world from emerging. Nor, as contemporary indigenous societies evidence, does it preclude the possibility of the continued existence of the denizens of those former worlds. I also suggest that the obsession with saving the present world creates a barrier to the emergence of a new one as humans in the majority world become ontologically 'locked in' to the past. It also risks generating resentment towards a possible future world and its lifeforms. This will be explored further in chapter 4 where I attempt to reconceptualise the sixth extinction to see it not solely as a time of crisis and loss, but also as a time of emergent possibility, where hope is still present, and the future is more open than is popularly imagined.

3.2 THE ANTHROPOCENE AS RUPTURE

Cultural theorist, Ursula Heise (2016), suggests that for many commentators the Anthropocene is simply a neologism that re-emphasises the overarching narrative that has long shaped environmentalist thought and discourse: that of the destruction and deterioration of nature under the impacts of modern societies. Over the past decade or so, it has become a catchphrase across a wide range of disciplines, with a plethora of books and thousands of journal articles including the word within their titles. The term as it was originally proposed by Crutzen and Stoermer (2000) sought to capture a radically new understanding of the extensive and deep-rooted nature of human impacts upon the planet. Earth System scientist, Will Steffen, explained the need for a new word this way:

> The term Anthropocene…suggests that the Earth has now left its natural geological epoch, the present interglacial state called the Holocene. Human activities have become so pervasive and profound that they rival the great forces of nature and are pushing the Earth into planetary *terra incognita*. The Earth is rapidly moving into a less biologically diverse, less forested, much warmer, and probably wetter and stormier state. (Steffen 2007:614)

Though the Anthropocene first emerged from within the geosciences to describe changes to the Earth System[4] and the planet's geology, it has now overflowed these spaces and is used much more inclusively. It has become a 'mega category' (Lorimer 2017) that serves as an umbrella term for contemporary environmental issues more broadly. The planetary-scale focus and 'elasticity' of geological time inherent within the concept have resulted in a more heterogeneous and speculative popular engagement with it that has driven conversations and collaborations across significant forms of epistemic difference. Much of the

4 The Earth System is defined as the suite of interacting physical, chemical, and biological global-scale cycles and energy fluxes that provide the conditions necessary for life on the planet. An important point to note is that biological and ecological processes are an integral part of the functioning of the Earth System and not just recipients of changes in the dynamics of a physio-chemical system (Steffen 2004). By this definition, a mass extinction would likely be a contributary driver of overall system change and the sixth extinction would thereby be considered one of the signatures of the Anthropocene.

vigour of the Anthropocene term, in fact, emanates from the wider debates this generates. Karera (2019) suggests that the power and popularity of the term "Anthropocene" testify to its ability to evoke in one single authoritative word a generalised planetary anxiety opened up by the realities of climate change, the possibility of the destruction of nature, and the end of the world as we know it.

Notwithstanding the broad interest, there is typically confusion and uncertainty about what the Anthropocene concept signifies, includes, or is even allowed to encompass and it has been subject to wide-ranging disciplinary interpretations. This has resulted in significant epistemological debate around the usage of the term (Hamilton 2015; Lewis 2015; Moore 2016; Hornborg 2017) as scholars have incorporated the idea into their research agendas. For Hamilton (2016), the move towards a more inclusive meaning of the Anthropocene outside of Earth System science, including the suggestions that there should be "multiple definitions" (Maslin 2015:1), risks diluting its ontological and scientific significance.

Whilst it is difficult to prescribe exact meaning to the Anthropocene, it seems to entail three definitional dimensions and two powerful and compelling claims that, it is suggested, call for new thinking in the social sciences and humanities (Hamilton 2017).

- A first definition proposes a new interval in geological history. This definition emerged within and has become inseparable from the intellectual community of Earth System Science.
- A second definition arises directly out of Earth System Science, around a shared complex system perspective of the Earth. In this definition, it is not about being able to detect human influence in stratigraphy but reflects a radical 'rupture' in the Earth System that has moved it outside the range of natural variability seen over the last half-million years.
- A third definition describes the broader aspects of human impacts upon the planet. This includes landscape transformation, species extinctions, modifications of the terrestrial water cycle, and significant alteration of the Earth's biogeochemical cycles. Together, these changes constitute shifts to the terrestrial biosphere not seen for millions of years.

There are two claims associated with these definitions:

- The first claim is that humans have become a 'new telluric force' (Crutzen 2002), changing the functioning of the Earth as much as volcanism, plate tectonics, the cyclic fluctuations of solar activity, or changes to the Earth's orbital movements around the sun.
- The second claim is that the human inhabitants of the planet will face, in a time-lapse of just a few decades, global environmental shifts of a scale and speed not

> seen since the emergence of the *Homo* genus 2.5 million years ago and certainly not during the ~ 300,000 years that *Homo sapiens* have been around.

These definitions and claims, which are grounded in natural science, confirm the Anthropocene is not simply a new word for common concerns about the deterioration of nature under human influence. It marks an ontological shift in the history of the planet and, as such, it is an entirely new way of conceptualising human-environment relations. The totalising implications also confirm that an individual species, humans, have impacted the global environment to an extent not matched since cyanobacteria (a microscopic species of algae) first added oxygen to the Earth's atmosphere 2.4 billion years ago,[5] triggering what may have been the first mass extinction – the disappearance of anaerobic bacteria – and a series of transformations that eventually led to the emergence of multicellular life (Lenton 2011).

To recognise humans as geological agents, as Chakrabarty (2009) states, dramatically scales up the imagination of what humans have ever been capable of. Since *Homo sapiens* first walked upon the planet, humans have always been biological and ecological agents both collectively and individually, altering the landscape, ecosystems, and other species as we go about our lives. That we have now collectively become geological agents on par with the great forces of nature marks a transition to a new phase of human experience that seems destined to be both qualitatively and quantitively different from any we have previously known. Humans have not simply become more powerful actors, but exponentially over time, we will become more vulnerable to the forces of the Earth. As we head further into the Anthropocene, we risk driving the Earth System on a trajectory that may lead to even more hostile states, climatic ones in particular, from which we may be unable to return (Steffen 2011). The Anthropocene, therefore, not only marks a rupture to the workings of the planet but also a rupture in the history of human experience.

The simultaneous awareness of human power and vulnerability and the "folding of the human and the geological" (Dibley 2012:1) results in the opening up of what Simon (2020:64) describes as "a new reality". Climate change and the sixth extinction are instances of new types of epochal events that have resulted in an epochal transformation that was completely unimaginable prior to awareness of the actual events themselves. The Anthropocene is therefore not only a new geological reality but also "a new epoch of thought" (Yusoff 2015:1) stretching way beyond the boundary of stratigraphy and Earth System Science. As Rowan (2014:447) notes, "The Anthropocene is…not simply a disputed designation in geological periodization but a philosophical event that has struck like an earthquake, unsettling the tectonic plates of conceptual convention".

5 Commonly referred to as the Great Oxidation Event.

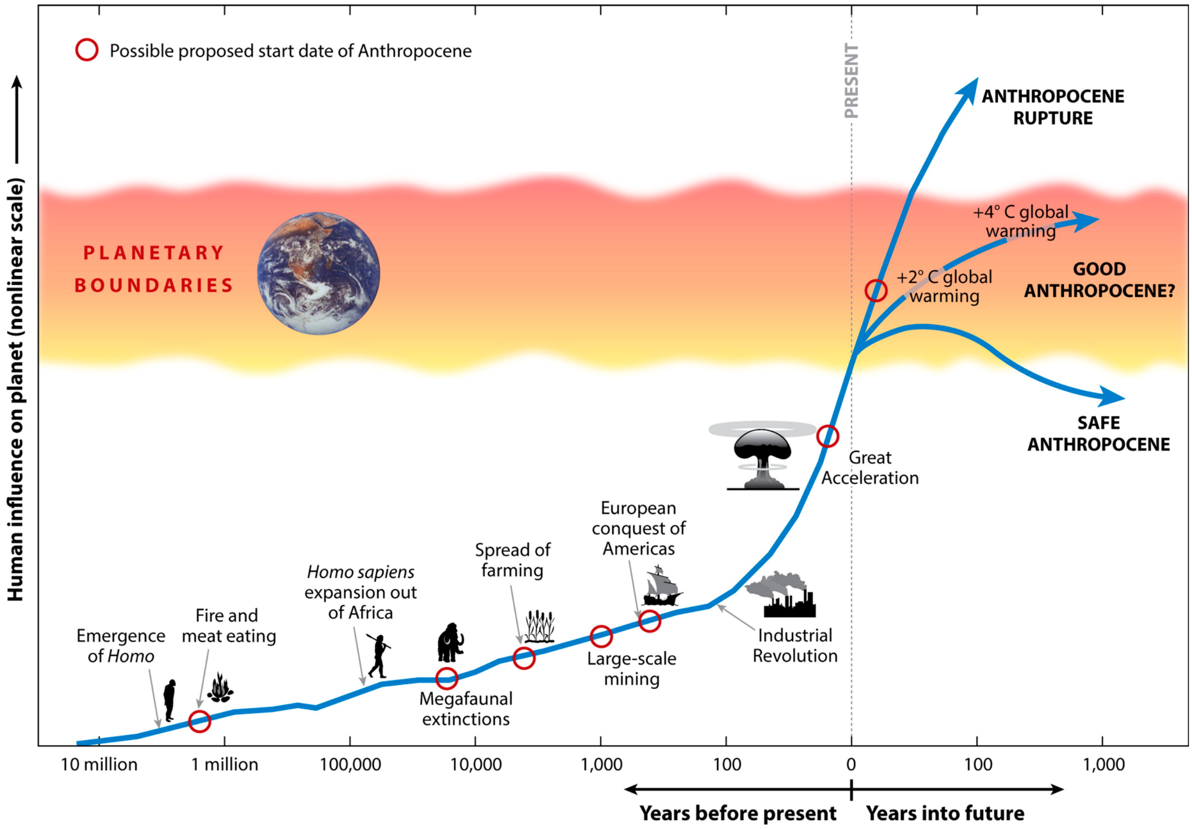


DIAGRAM 3.1 A timeline of increasing human influence upon the Earth System
Source: Mahli (2017)

3.3 ECO-CATASTROPHISM AND THE APOCALYPTIC IMAGINARY

The recognition that humans have now left the Holocene (Waters 2016) and are living in a 'no-analogue world' (Steffen 2015) has prompted several institutional and philosophical responses. One of the most common and instinctive of these has tended towards scientifically informed management and planetary stewardship (Steffen 2011). It implies that with informed consideration, humanity can avoid breaching 'planetary boundaries' (Steffen 2015) and steer the human-natural world into an altered but sustainable future. This approach to responding to the Anthropocene is arguably implicit within much of the Earth System Science discourse. Another reaction has been the suggestion that the Anthropocene is an inevitable and perhaps even desirable epoch that presents a significant opportunity for humans. Beyond simply trying to diminish the planet's human footprint, this philosophy argues for what has been described as 'enlightened anthropocentrism' (Hamilton 2016) where, with knowledge of past mistakes, humanity can both manage and direct its impacts to deliver a "good Anthropocene".[6] The most prominent vision of this has been termed

6 "As scholars, scientists, campaigners, and citizens, we write with the conviction that knowledge and technology, applied with wisdom, might allow for a good, or even great, Anthropocene. A good Anthropocene demands that humans use their growing social, economic, and technological powers to make life better for people, stabilize the climate, and protect the natural world" (Breakthrough Institute 2015:6).

'ecomodernism' (Breakthrough Institute 2015). The ecomodernist doctrine proposes that on a planetary level, human societies should, en masse, embrace high technology solutions such as nuclear power and genetically modified crops, combined with actions that encourage a 'decoupling' of humanity from nature, including facilitating the mass migration of humans to cities. Ecomodernism has been strongly criticised for a variety of reasons. These include its inadequate recognition of the exploitative, violent, and unequal dimensions of technological modernisation (Buck 2019), its explicit humanism (Crist 2017), and its continued reliance upon economic growth (Grunwald 2018). For Colebrook (2017:18), "Any "good" Anthropocene would be possible only by way of countless injustices".

An alternative and more prevalent response to the Anthropocene presents a more alarmist view of the future. In what has been termed the 'eco-catastrophist' (Bonneuil 2015) or 'disaster' (Rothe 2019) perspective, this altogether different interpretation emerges from the call to recognise the Anthropocene as a rupture to the Earth System, as described in the previous section, where we are facing a 'Hothouse Earth' that is well beyond the control of humans (Steffen 2018), the 'biological annihilation' of planetary life (Ceballos 2017), and a time of heightened suffering (Northcott 2015) where humans find themselves in a global state of precarity and vulnerability (Tsing 2015). It emphasises that the Anthropocene is an epoch where modernity's aspirations towards indefinite growth and progress have collided with the finitude of the Earth (Malhi 2017), raising the likelihood of tipping points (Lenton 2013) and planetary state-shifts (Barnosky 2012). It suggests there is a realistic possibility of societal and planetary collapse and human extinction (Ord 2020). Even if humans survive, the future is ultimately imagined as being much worse than the present and there is little faith that science and technology will offer ultimate salvation.

Eco-catastrophism recognises that humans are effectively returning to the status quo of climatic instability that was prevalent throughout much of the Pleistocene[7] and before. Far from the Earth providing a stable background that fosters human and biological development that can be managed or stewarded, there is a new appreciation of it as an unpredictable and potentially hostile entity that needs to be treated with fear and trepidation. Lorimer (2017:28) has described this as the "return of the repressed, the power of an inhuman nature to tip the planet out of the benign climate envelope of the Holocene, withdrawing the fundamental grounds in which modern (and other forms of) civilisation came into existence and replacing them with more energetic, unstable, and hostile conditions". Hence Gaia (the Earth System), is not or no longer the benevolent, nurturing 'Mother Earth' of the 19th century Romantics, but the half-crazed, bloodthirsty, and vindictive goddess of the original Greek tales (Latour 2011).

Numerous scholars have identified an underlying apocalyptic tone to the Anthropocene discourse (Dürbek 2019; Sloterdijk 2015; Northcott 2015). Humanity has been identified as a

7 The Pleistocene epoch is commonly defined as the geological period that began about 2.6 Mya and lasted until about 11.7 kya and is characterised by multitemporal change between cold and warm periods.

'planetary killer' concerned only with its own short-term survival (Wilson 2001). The 'collapse of Western civilisation' is deemed inevitable (Oreskes 2014), and we are now 'living in the end times' (Žižek 2011), where we are experiencing the 'revenge of Gaia' (Lovelock 2007) that will soon result in 'the world without us' (Weisman 2007). Though an apocalyptic logic within environmentalist discourse is nothing new – Skrimshire (2014) has identified the consistent presence of themes and concepts from Christian and Jewish apocalypse since the birth of environmentalism – as Zylinska (2017) points out, it has been given a whole new lease of life in the Anthropocene, providing a ready-made framing device for humans to understand the new epoch.

It has been suggested by Rothe (2019) that much of the discourse on the Anthropocene can be read as a form of secular eschatology, which refers to the Christine doctrine of the last of things and is concerned with the final events in history. Central to eschatology[8] is the idea of linear time moving forward from a starting point (creation) towards a final event in the divine plan (the eschaton). Early Christian thinkers like St Augustine (354-430 CE) developed such an understanding of time in opposition to ancient Greek philosophy, which had conceived of time and history as eternally recurring cycles. Unlike cyclical time, the linear model of eschatology allowed accounting for change and progress, including the possibility of writing a human history that was able to distinguish clearly defined periods and epochs. At the same though, the notion of linear time also brought with it the question of how time will end, something which is the subject of ongoing debate amongst theologians. Christian political theology has always been eschatological, but not necessarily apocalyptic. Apocalypse refers only to a specific eschatological genre, namely the belief in an imminent cataclysmic intervention by God in history (Northcott 2015).

Apocalypse is the Greek title of the last book of the Christian Bible, *Revelation*, and means 'unveiling' or 'uncovering'. Though there is no agreement about the exact characteristics of apocalypse, according to McQueen (2017), the apocalyptic imaginary is centred around five core beliefs:

- The end of the world is imminent
- The imminent rupture will be equally cataclysmic and transformative
- It will bring an end to an identified evil
- It represents a rupture in an otherwise undisrupted linear flow of history
- It involves the revelation of the secrets written in heaven

As a moment of revelation, the coming of the eschaton – the end of the world – by a sudden apocalypse was expected to lead to the creation of heaven on Earth and referred

8 The branch of theology concerned with 'the last things' – death, what follows it for each individual, and the final fate of the universe. According to traditional Christian theology, death is followed by the resurrection of the dead, God's judgement on their past life, and their apportionment to either heaven or hell (Honderich 2005).

to the possibility of overcoming the power structures of the present world. The cataclysmic intervention by God in history was a purifying event that swept away the meaninglessness of the world for a higher end. The Christian apocalypse has therefore always been considered both a profoundly pessimistic *and* optimistic affair.

IMAGE 3.1 Allegory of the apocalypse
Artist: Heintz, Joseph (1674), reproduced from Wikipedia (2022)

The extent to which the science-based, secular apocalypse of the Anthropocene can be given equivalence with the core beliefs of the Christian apocalypse is, of course, interesting to ponder. But it is not the main focus here. What I am more interested in is the meta-language of what is being inferred when apocalyptic tropes, expressions, and claims are used to describe the vulnerabilities that humans face in the Anthropocene. It seems reasonable to suggest that commentators who state or imply that we are heading towards the 'end times' (the eschaton) typically imagine that it will be something less transformative than the opening of the seven seals and the creation of a New Jerusalem on Earth where all the Christians live happily ever after, as envisaged in *Revelation*. What is not always clear, though, is precisely what end times are being imagined? When Danowski (2016:Ch2), for example, declares "The Anthropocene is the Apocalypse, in both the etymological and eschatological senses", what is the cataclysmic end-state she ultimately foresees? Is it, to use her terms, a 'world without us' where humans become biologically extinct and disappear? Or is it an 'us without world', where humans survive organically but are shorn of the world in an ontological sense? And to this latter speculation, we might also speculatively add, is there a chance of another, different world to come?

The proceeding sections will explore these possibilities, beginning with a consideration of human extinction. Taken literally, human extinction would seem to mean something rather straightforward – the discontinuation of humans as biological entities. Probing the discussions, though, reveals that human extinction also, and perhaps mostly, seems to mean extinction in an ontological sense.

3.4 HUMAN EXTINCTION

Though humans have been predicting 'the end times' since the beginning of history, as touched upon above, it is only over the past two centuries or so that most Western-educated people have learnt to admit that one day *Homo sapiens* will cease to exist forever. In Lévi-Strauss' oft-quoted statement, we now know that "the world and life started without us and will end without us" (Lévi-Strauss 1976:Ch40). As described in the previous chapter, scientists such as Georges Cuvier, in his catastrophic speculations about the deeper history and overall functioning of the Earth, had, at the beginning of the 19th century, suggested that humans were at risk of absolute disappearance. But as noted, it was not until the publication of *On the Origin of Species* in 1859, when Darwin confirmed the finitude of all species under the ongoing process of natural selection, that the possibility of human extinction began to be accepted as fact.

This discovery, of course, was no minor philosophical event. Whilst Darwin famously underplayed the spectre of human extinction as part of his theory of evolution, Freud later identified it as one of the 'great humiliations' of modern society. The recognition that humans had parity with other (lesser) species and under natural processes were just as likely to disappear was seen as a wound to the privileged standing of 'Enlightenment man' (Malazita 2017). More recently, it has been suggested that the discovery of human extinction was path-breaking and deserves to be recognised as one of, if not *the* most important achievement of modernity. As Moynihan (2020:Introduction) states, "What other Earth-born species can think upon its own demise – let alone take responsibility for it by using science to predict and perhaps prevent it? No other animal on the planet can assume liability for its own fate in this way".

In cosmological timeframes, the sub-field of astrophysics, known as physical eschatology, establishes that human extinction is inevitable at some point (Bostrom 2004). Quite when this will happen is, of course, unknown, but we do have a few indicators. Based on what we know about Earth history, the average life span for mammals in the Cenozoic[9] is about 3 Myr (Margulis 2000). *Homo sapiens* have thus far been around for between 200-300 kyr (Reich 2018)

9 The Cenozoic is the Earth's current geological era, representing the last 66 Myr of history. It is characterized by the dominance of mammals, birds, flowering plants, a cooling and drying climate, and the current configuration of continents (Gradstein et al. 2020).

which would suggest that from a mammalian perspective at least we may be at the early stages of our life span. From the history of our genus, *Homo*, there is strong evidence that *Homo erectus* lasted over 1.7 Myr and *Homo habilis* lasted 700 kyr (Snyder-Beattie 2019). The median hominin temporal range thus far is about 970 kyr (Robinson 2018). This again suggests that our existence to date is far from excessive. *Homo sapiens* may, in fact, be at lower extinction risk than other species from the *Homo* genus and mammalian species overall because of our wide habitat range, large population, and having a generalist diet, which are all traits that mitigate extinction risk (Purvis 2000). With these and other factors in mind, Watson (2019) suggests that, under natural circumstances, *Homo sapiens* could conceivably survive another 7.8 Myr. With conditions supporting complex, multi-cellular life predicted to continue for about a billion years (Mello 2020), this represents a small percentage of the remaining history of life on Earth. It also suggests that the disappearance of *Homo sapiens* and all other life forms will not be coterminous – the wider universe and life will continue after we are gone. Obvious though this may seem, it is normally not a feature of religious eschatological traditions discussed in the previous section, where the termination of humanity inevitably results in the termination of the entire world (Moynihan 2020). As I will later discuss, such a view is also prevalent within contemporary secular end-of-world fears.

Though humans have been alert to the possibility of biological extinction since Darwin's day, concerted thinking about it is primarily a phenomenon of the post-atomic age. It was only after the detonation of the world's first nuclear weapon in the desert of New Mexico in July 1945 that human extinction moved from a remote possibility to seeming like an 'imminent danger' (Ord 2020). This also, of course, marked the point that humans, through their technological innovations, first attained the capacity for self-extinction, a moment Ord (2020) in his book of the same name terms the 'the precipice'. From around this time, the Bulletin of Atomic Scientists devised the idea of the Doomsday Clock, which purports to represent the likelihood of a human-made global catastrophe. Maintained since 1947 and now updated annually, the clock is a metaphor for the threats to humanity from unchecked scientific and technical advances. It represents the hypothetical global catastrophe (the end of human existence) as midnight and the Bulletin's opinion about how close the world is to it as the number of minutes or seconds to midnight. Its most recent iteration, in January 2022, assessed that we are now 100 seconds away, the closest we have ever been.[10]

Despite the obviously profound implications of human extinction, scholarly attention given to it has, until very recently, been scant (diagram 3.2).[11] Quite why this is the case is unclear. Bostrom (2013) suggests that research may be inhibited by the multi-disciplinary

10 To view the timeline of the assessments since 1947 and for further information about the Bulletin of Atomic Scientists, see https://thebulletin.org/doomsday-clock/timeline

11 This is not to deny the preoccupation with human extinction within the broader social sphere over the last half-century or so. As theorist Clare Colebrook (2014) has described, the desire of Western people to contemplate the total and irreversible destruction of the planet has now become a central theme of popular culture.

nature of the problem, but also by deeper epistemological and ethical issues. He also believes theoretical and moral difficulties are compounded by psychological factors that make it difficult to think rationally about a topic such as the end of humanity. Such a paucity of research raises a question about the eschatological nature of the Anthropocene discourse described above. Given the limited research, it is not clear upon what empirical basis humans are judged to be at risk of extinction.

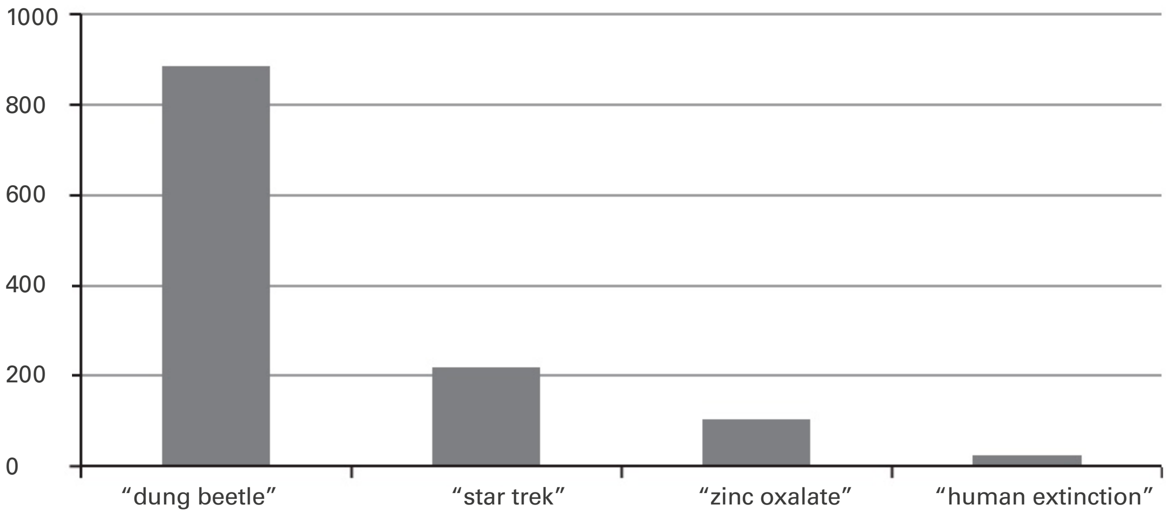


DIAGRAM 3.2 Research on human extinction
Source: Bostrom (2013)
Number of academic papers on various topics (listed in Scopus, August 2012)

An emergent area of research directly related to the issue of human extinction is the field of 'existential risk studies'. The field has its roots in the work of German sociologist Ulrich Beck's work in the 1980s on what he terms the 'risk society'. His book of the same name argues that modernisation has inherently led to "social production of risks" as a consequence of the generation of wealth under modernity (Beck 1992:19). These risks manifest in the form of ecological disasters or industrial accidents and ultimately result in a "catastrophic society" where "emergency threatens to become the normal state" (Beck 1992:79). Beck's core ideas about societal risk under modernity were taken up and a decade later applied to research on human extinction. This resulted in the publication of a seminal paper by Bostrom in 2002, 'Existential Risks: Analysing Human Extinction Scenarios and Related Hazards'. Since the mid-2010s, numerous organisations focused on studying existential risks have emerged, notably at Oxford and Cambridge universities. As the environmental crisis unfolds, it is likely to become a major research area over the coming years.

There are various definitions of existential risk, but probably the most commonly used is by Bostrom from his above-referenced paper. He states an existential risk is, "One where an adverse outcome would either annihilate Earth-originating intelligent life or permanently and drastically curtail its potential" (Bostrom, 2002:2). This illustrates that the concerns and focus of research are not solely about the biological disappearance of *Homo sapiens* (or future lineages thereof), but also about the *loss of potential*. On this, Ord (2020:Ch2) states, "Existential risks threaten the destruction of humanity's potential. This includes cases where this destruction is complete (such as extinction) and where it is nearly complete, such as a permanent collapse of civilization". Losing our potential[12] is not limited to human extinction or civilisational collapse. It could also involve a situation where humanity gets "locked into a bad set of futures" (Ord 2020:Ch5). This could be a world with civilisation intact but trapped in a terrible form, with little or no value – an unrecoverable dystopia. The imminent conditions of the Anthropocene, perhaps.

It is difficult to calculate the probability of existential risks and most attempts, particularly those relating to contemporaneous risks, rely heavily on subjective judgement (Bostrom 2013). There are many reasons to suppose, however, that the total risks confronting humanity in the Anthropocene are greater than humans have experienced previously. It is also likely that as well as the known risks of the present, there will be more that lie beyond the limits of our existing knowledge and vision. If we imagine the scientific establishment of the 1920s had been asked to compile a list of the common risks humanity would face over the following century, they would probably have missed many of those identified as significant today including risks caused by species loss, climate change, and nuclear war.

Homo sapiens have been exposed to and survived natural existential risks for hundreds of thousands of years. This includes glaciation events, such as the Late Glacial Maximum (26-20 kya) when ice sheets covered much of North America, Northern Europe, and Asia, profoundly affecting Earth's climate by causing drought, desertification, and a large drop in sea levels (Clark 2009). It also includes the Youngest Toba super-volcanic eruption in Indonesia (74 kya), one of the largest known eruptions in the geological record that may have caused a 'genetic bottleneck' reducing the human population to as few as 3,000-10,000 individuals (Rampino 2000).[13] Based on an assumption *Homo sapiens* have existed for 200 kyr,[14] Snyder-Beattie (2019) calculates the chance of our species going extinct in any given year from 'naturally occurring processes' to be between 1 in 14,000-87,000. These bounds are, apparently, consistent with mammalian extinction rates, typical hominin species lifespans, the frequency of well-characterised risks, and the frequency of mass extinctions.

12 Ord (2020:Ch2) defines humanity's potential as "the set of all possible futures that remain open to us. This is an expansive idea of possibility, including everything that humanity could eventually achieve, even if we have yet to invent the means of achieving it".

13 This claim has come under significant scrutiny and evidence has recently been discovered suggesting *Homo sapiens* in Southern Africa may have been mostly unaffected. See, for example, Smith, Eugene I., et al. 2018. "Humans Thrived in South Africa through the Toba Eruption about 74,000 Years Ago." *Nature* 555 (7697): 511–15.

14 Noting that the current upper limit of estimates is 315 kyr. See Hublin, Jean-Jacques et al. 2017. "New Fossils from Jebel Irhoud, Morocco and the Pan-African Origin of Homo Sapiens." *Nature* 546 (7657): 289–92.

Though *Homo sapiens* have survived natural existential risks since we first walked upon the Earth, humanity has recently introduced entirely new anthropogenic risks that we have no prior history of navigating. These risks form the bulk of the existential risk we face in the future (Bostrom 2013) and as such our current and forecasted longevity as a species based on natural risks offers no strong ground for confident optimism. Most anthropogenic risks we are exposed to involve the dynamics of the natural world but almost all are in some way connected to the development of human technologies which either generate or facilitate the risk. The enormous coupling of humans with their technologies has led some to suggest that 'Technocene', rather than Anthropocene, is a more appropriate term for the new geological epoch (Hornborg 2015). It has also been suggested that the capacity for technology to modify the core processes that drive Earth System dynamics is such that it must be considered a new dimension of analysis in the study of the Earth System in its coevolution with life and in particular humans (López-Corona 2020). Evolution and technology, it is proposed, can no longer be separated.

Two of the most common areas of focus of the Anthropocene discourse relate to the issues of climate change and species loss. Whilst many scholars would agree that anthropogenic climate change poses an existential risk, it is not believed that it will directly bring about our extinction (Thomas 2014). Rather, it is far more likely to result in the breakdown of civilisation (Torres 2019). From an existential risk perspective, a more serious concern is that the higher temperatures and the speed of change, where species are unable to adapt to the new conditions (Bellard 2012), might cause a large loss of biodiversity and subsequent ecosystem 'collapse'. Whilst the pathway is not entirely clear, a large enough 'collapse' of ecosystems across the globe driven by changes to the Earth System and the biosphere more widely through the likes of landscape transformation could potentially threaten human extinction (Ord 2020). This possibility also draws attention to the interlinked nature of existential risks and how the manifestation of risk in one area can proliferate into larger responses and reactions in other areas.

The bulk of existential risk over the next century resides in scenarios that *Homo sapiens* lack historical precedent. This makes it difficult to assign precise probabilities of their occurrence. However, as Bostrom (2013) points out, just because many of these risks are difficult to quantify does not imply that the risk is negligible. Toby Ord, from Oxford university's Future of Humanity Institute, has attempted to evaluate the known natural and anthropogenic risk humans will be exposed to over the next century. He calculates that the chance of an existential catastrophe caused by natural events is about 1 in 10,000 (table 3.1). For anthropogenic risk, his predictions are far more alarming. He states,

> During the twentieth century, my best guess is that we faced around a one in a hundred risk of human extinction or the unrecoverable collapse of civilization. Given everything I know, I put the existential risk this century at around one in six: Russian roulette. (Ord 2020:Ch1)

To be clear, Ord is suggesting there is a 17% chance of an existential catastrophe occurring over the next century that would result in either human extinction, civilisational collapse, or an unrecoverable scenario where humanity gets locked into a 'bad' set of circumstances it is unable to escape from. This aligns with Sandberg (2008) who based on a survey of various researchers estimates there is a 19% chance of human extinction prior to 2100. Rees (2004) estimates there is a 50% chance of civilisational collapse during the 21st century.

Existential catastrophic risk	Chance within the next 100 years
Asteroid or comet impact	~ 1 in 1,000,000
Supervolcanic eruption	~ 1 in 10,000
Stellar explosion	~ 1 in 1,000,000,000
Total natural risk	**~ 1 in 10,000**
Nuclear war	~ 1 in 1,000
Climate change	~ 1 in 1,000
Other environmental damage	~ 1 in 1,000
Naturally' arising pandemics	~ 1 in 10,000
Engineered pandemics	~ 1 in 30
Unaligned artificial intelligence	~ 1 in 10
Unforeseen anthropogenic risks	~ 1 in 30
Other anthropogenic risks	~ 1 in 50
Total anthropogenic risk	**~ 1 in 6**
Total existential risk	**~ 1 in 6**

TABLE 3.1 Chances of an existential catastrophe over the next 100 years
Adapted from Ord (2020)

Research into the nature and mitigation of global catastrophic and existential risks is subject to a unique set of challenges and as such cannot easily be subjected to the usual standards of scientific rigour described by Oreskes (2019) in chapter 1 of this thesis. It is therefore difficult to know exactly how to interpret or respond to estimates such as Ord's, above, which in their highly speculative nature and lack of empirical grounding fall outside customary scientific frameworks and norms. At the very least, they seem to support the worst fears of commentators who claim the arrival of the Anthropocene marks a time of "hyper catastrophe" (Bińczyk 2019:10), exposing us to levels of risk never experienced over the entirety of the Holocene and maybe ever. Humans may be more powerful than they have ever been, but they have also probably never been as vulnerable.

A clear problem with many of the existential risk assessments is understanding precisely what is at stake. Risks associated with civilizational collapse and human extinction are invariably conflated, and the collapse of society is seemingly given equivalence with the outright discontinuation of humans as biological entities. This vagueness, I suggest, is also present within some of the discourse on the species extinction crisis and the Anthropocene. For example, when Ceballos (2020:13601) states, "The extinction crisis…poses an existential threat to civilisation", or Steffen (2018:8256) states, "Hothouse Earth is likely to be uncontrollable and dangerous…and it poses severe risks for…the habitability of the planet for humans" it is not clear if they are suggesting biodiversity loss and climate change will cause the collapse of society or the disappearance of humans.

Another intriguing aspect of existential risk research is how concerns about human extinction are explicitly bound up with fears about the loss of human 'potential'. This loss of potential risks creating "a world bereft of human flourishing" (Ord 2020:2) which is seemingly given parity with human extinction. In other words, if humans fail to reach their potential as a species (what this means is not fully clear), and 'lose control' of the future, then it will represent a failure akin to our actual biological disappearance.

Mitchell (2020) has suggested that the discourses on global catastrophic risk, human extinction, and similar large-scale threats are not, in fact, concerned about the end of the Earth or the total disappearance of *Homo sapiens* (although the latter certainly seems plausible, not least through nuclear annihilation). They see the collapse of the currently dominant power structures as the 'end of the world' and thereby the 'end of humanity'. This suggests that the Anthropocene is not only a marker of an ecological crisis, evidenced by the rupture of the Earth System and biodiversity loss, but also a cultural and psychological crisis linked to fears about the loss of a particular way of life, something I will next discuss.

3.5 THE END OF MODERNISM (AS THE END OF THE WORLD)

There is typically little confusion about what the extinction of other species means, something that has, more or less, a clear and operationally accepted definition.[15] However, the meaning is more difficult to pin down with human self-extinction, which is not necessarily understood as simply the dying out of the human species. As noted in section 3.3, the eschatological nature of the Anthropocene and sixth extinction discourses project the idea that we are rapidly heading towards 'the end times' driven by human impacts upon the natural world. Quite how this end will manifest, though, seems open to interpretation. Civilisational collapse, the loss of human 'potential', an un-recoverable dystopia where humans find themselves locked into a 'bad' set of environmental conditions, and even perhaps the termination of planetary life, all seem to fall within the rubric of human extinction, stretching way outside any biological meaning.

Regardless of whether humans are imminently running into any of the above, something that is unclear at this point, we do seem to be experiencing an ontological crisis with increasing pessimism and insecurity towards the future. As Clark (2014) notes, the Anthropocene is the disaster to end all disasters. It is the event that threatens the very possibility of thought, meaning, identity, and crucially, purpose. Providing inhabitants with purpose or telos is,

15 The International Union for the Conservation of Nature defines a species as extinct when "there is no reasonable doubt the last individual has died" (IUCN 2012:12).

according to Lear (2007), a fundamental task of any robust culture. This is a sense of why life is valuable, what it is like to flourish as a human being, the central concepts with which members of the culture can understand what is good and bad, true and false, valuable and useless about the world, and also a belief in its future. The precarity of the Anthropocene, though, is a world without teleology – a world of indeterminacy and uncertainty where we cannot rely on the status quo. Everything is in flux, including our capacity to even survive (Tsing 2015). For those raised with the expectation of stability and never-ending progress, this is a serious blow – one of the 'shocks' of the Anthropocene (Bonneuil 2016).

The notion of continual progress and the broader confidence in the 'modern' way of life are said to be severely compromised by the Anthropocene. As humans become agents of 'geohistory' (Latour 2014) the core ideas of the dominant civilisational model over the past few centuries – modernity – are vulnerable to collapse. The Anthropocene, according to Chandler (2017:80), "destabilises the very ground on which the fragile façade of modernity rests". If the arrival of modernity and the idea of a mechanical, secular universe operating to a set of physical laws went against the grain of the common understanding of the world at the time, in the same way through what Latour (2014) describes as a 'counter Copernican revolution', so the arrival of the Anthropocene and the realisation that there are no 'modern solutions for modern problems' (Blaser 2009) contradicts the understanding of the world ushered in by modernity.

Modernity is both a historical period – the modern era – and an ensemble of particular socio-cultural norms, attitudes, and practices that arose in the wake of the Renaissance (Berman 1988).[16] Depending on the intellectual field (social sciences, literature, art), it can signify different characteristics and time periods, but it is commonly thought to refer to a powerful set of cultural, political, economic, and spatial relationships that have fundamentally influenced the nature of social life, the economy, and the use and experience of time and space (Linehan 2009). The characteristics of these relationships are many and varied (capitalist, liberal, secular, patriarchal, individualist, amongst others), but according to Pálsson (2006) they are built upon three primary beliefs:

- Dualism of nature and society, otherwise known as the nature/culture divide
- Emphasis of science and rationality over tradition and myth
- Assumption of linear control and continual progress

16 The Renaissance (14th-17th century) is a period in European civilization immediately following the Middle Ages and is conventionally held to be characterized by a surge of interest in Classical scholarship and values. It also witnessed the discovery and exploration of 'new' continents, the replacement of the Ptolemaic system of astronomy with the Copernican one, the decline of the feudal system, the growth of commerce, and the invention or application of powerful innovations such as paper, printing, the mariner's compass, and gunpowder. To the scholars and thinkers of the day, it was primarily a time of the revival of Classical learning and wisdom after a long period of cultural decline and stagnation (Campbell 2005).

Thus, Gudeman (1992:151) defines the "modernist production regime" as a regime based on the idea that the "human and natural world can be organised and subjected to rational, totalising control". Anthropologist James Scott (1999:Ch3) uses similar terms. For him, modernism is characterised by "supreme self-confidence about continued linear progress, the development of scientific and technical knowledge, the expansion of production, the rational design of social order, the growing satisfaction of human needs, and, not least, an increasing control over nature (including human nature) commensurate with scientific understanding of natural laws." Whilst it is difficult to say precisely when modernity began, an articulated version of it emerged in the 15th century with the rise of capitalism and the emergence of strong centralised states (Linehan 2009). For historians, the 17th and 18th centuries are usually described as early modernity, whilst the 'long 19th century'[17] comprises 'modern history' proper, during which time its ideas and practices became more widely adopted (Berman 1988).

The dominant characteristic of modernity is usually considered to be humankind's separation or 'emancipation' from nature (Orr 2015, Latour 2011). Before modernism, there was no radical separation of nature and society in European thought. In the world of the Ancient Greeks, humans were very much part of nature. Their destiny was not separated from the 'eternal cosmos' and it was by virtue of the fact they were able to accede to knowledge of the laws that governed it that they were able to find their place amongst it (Descola 2013). Christianity, with its twofold idea of the transcendence of man and a universe created from nothingness by God's will, progressively transformed this idea. By the 17th century, the idea of a separation between nature and the world of humans began to gain acceptance and by the Enlightenment, human apartness had been consolidated by a strong form of reductive materialism whose project, in the words of Descartes, was "the empire of man over things" (Plumwood 2009:119). What came into existence was the idea of nature as an autonomous ontological domain. It was a field of enquiry for scientific experimentation and an object to be exploited and improved. Anthropologists have been able to identify that nature is not a universal category shared by all people and is, in fact, a social construct of European society.[18] Despite this, the concept is now so firmly established in Western thought, it is no longer considered a philosophical concept or even a scientific term (Ducarme 2020).

A central proposition of the Anthropocene discourse is that there is no longer any nature left untouched by human activities and as such it cannot be considered a separate

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17 The 'long 19th century' is a term coined for the 125-year period comprising the years 1789 through to 1914. It expresses the notion that the period between 1789 (the start of the French Revolution) and 1914 (the beginning of the First World War) reflects a major progression of ideas characteristic to an understanding of 19th century Europe (Hobsbawm 2001).

18 There is a long and complex history pertaining to the divide between nature and society in European thought. The full details of this are outside of the scope of this chapter, however readers are referred to, Descola, Philippe. 2013. *Beyond Nature and Culture*. University of Chicago Press.

ontological and physical domain to human affairs anymore (Chakrabarty 2009). This had led to the claims that nature has 'ended' (Ellis 2009) and that we now live in a 'post-natural' world (McKibben 2010). These claims have a twofold meaning. First, the scale of the human footprint upon the planet is such that natural processes can no longer be defined as independent from human influence. Second, natural forms and processes have been influenced by humans to a high degree. Sometimes this influence is discernible, other times it is not. In certain instances, such as with climate, it is not even planned. But from a philosophical standpoint, it does not make any difference: what separates anthropogenic influence upon a remote forest and an urban park is only a matter of degrees. From this point of view, nature can no longer be defined by its independence from humans and society, and we are therefore living 'after nature' (Purdy 2015). To put it simply, the Anthropocene confirms that society and nature are not two separate entities influencing each other, but rather that there exists a socio-natural entanglement – that is, an irreversible, complex, and increasingly hybrid socio-natural system that humans are unable to step outside of (Maldonado 2016).

If we are now living 'after nature' or amongst its 'ruins' (Tsing 2015), we also, according to Latour, find ourselves more and more living in the ruins of science, something that until very recently dreamed of "unifying the cosmos" (Latour 2011:9). Over the past few centuries, scientific accomplishment has provided a principal resource for optimism, confidence, and celebration of dominant Western cultural practices and thought. It has provided a legitimising narrative for the prevailing order that has sustained itself through its achievements (Hamilton 2017). Increasingly, however, it finds itself under siege from within. The scientific discoveries of elevated CO_2 levels and species extinctions appear to be dramatic exceptions to the pattern. Dire warnings about anthropogenic climate change and a major reduction in global biological diversity, driven at least in part through activities deemed to be the fruit of advances in scientific knowledge, call into question our assumptions about the scientific enterprise and the uses to which it has been put (Chernela 2012). That these issues were discovered through the material advances of science, via its instruments and sensing technology, confirms that "our cognitive powers have become self-defeating" (Morton 2013:160). As Chandler (2018:Ch1) notes, "Science has itself called a halt to modernity in its recognition of the Anthropocene condition." This is not to suggest the new geological epoch spells the end of science – as noted in section 3.3, above, the instinctive response to the Anthropocene has often been towards scientifically informed management and planetary stewardship. Rather, it spells the end of science as the cheerleader for modernist discourses of progress, a concept I will next discuss.

From the 17th century onwards, expectations arose amongst European thinkers that a comprehensive and sustained improvement of the human condition was possible. Not only was such improvement possible, but it was likely to happen anyway because insight had been gained into the conditions for it to emerge. This was the result of the invention of progress as a comprehensive evaluative political concept (Wagner 2017). In comparison with any view of human improvement held before, the idea of progress marked a radical break. It connected normative advances in the human condition with a long linear perspective – not only would life improve, but it would do so indefinitely into the future, and continued human flourishing was guaranteed. A positive transformation in the human condition was seen as being on the horizon of history, a transformation of such a radical nature that had never been considered even remotely possible before. The idea of a new form of society had emerged, one that was seen as evolving according to a different logic than any preceding one, namely with an open horizon of future possibilities (Mouzakitis 2017).

The Enlightenment thinkers who believed and promoted this radical new idea shared a basic assumption upon which everything else was constructed – humans were capable of autonomy and were endowed with reason. Reason allowed them insight into the problems they were facing and the development of the means to solve them. Autonomy allowed them to choose the adequate means and to take the appropriate action. This is what enables improvement in terms of solving problems. Furthermore, human beings have memory and can learn so rather than each generation having to address the same problem again successive generations can build on the achievements of the earlier ones and improve on them. This connection of reason, autonomy, and learning capacity, it was said, created the conditions for the progress of humankind, allowing them to exit from the 'self-incurred immaturity' of the past (Kant 1784).[19]

According to Stengers (2015), the arrival of the Anthropocene confirms that the modernist expectation of continual progress and a guaranteed 'happy ending' is now over. This is echoed by Bonneuil (2016:Ch2), who states that the promise of catastrophic global warming, climate change, species extinction, and ocean acidification confirms "There can be no more talk of a linear and inexorable progress". For Chandler (2018:Ch1), the modernist telos that striving harder would lead to collective betterment, "now seem no more emancipatory than religious promises of justice in the afterlife". The Anthropocene also brings with it another perhaps even more frightening possibility - the risk of regression or 'de-evolution' (Mitchell 2020) where 'advances' in the human condition over recent centuries are lost. As Ghosh (2014) notes, for modern humans, the only thing that evokes greater terror than being left behind is the thought of going backwards, or as Kant might say, 'falling back into immaturity'.

The Anthropocene, therefore, challenges what has been identified as the fundamental concepts that underpin the dominant modernist worldview: first, the ontological divide between nature and society and the belief that humans exist on a plane above the base material world

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19 The obvious question arises as to why it was considered there had not been more sustained 'progress' in human history before the end of the 18th century. The answer given at the time was that humans, up until that point, had not been free to make full use of their capacity to reason, and had been living under various forms of domination. The Enlightenment, it was reckoned, changed this. Once the conditions for human beings to live autonomously and reason were freely created, then progress would impose itself and could no longer be stopped (Wagner 2016).

around them; second, the deep faith in the Western scientific enterprise and the idea that scientific advancement guarantees a pathway to a better future; and third, the conviction of never-ending progress and the belief that a sustained improvement of the human condition is possible. The realisation that these guiding principles that have shaped Western thought and action over the past few hundred years are incompatible with the reality of the world is something LeCain (2016:16) has described as the "Great Ontological Collapse". The modernist future once considered inevitable has now all but disappeared. Humans are no longer in control of their common fate, something Hamilton (2017:Ch4) suggests marks the end of the modern era and which he thinks is the "inner meaning of Anthropocene science".

Whilst humans have never been more potent nor exercised such dominion over nature, as described in section 3.2, we are also simultaneously vulnerable to the power of natural forces in a way we have not experienced since the retreat of the last great ice sheets 12,000 years ago. Paradoxically, therefore, humans have not "slipped the surly bonds of the Earth" (LeCain 2016:16) and emancipated themselves from nature as they imagined they had under modernism. Rather, as a result of their 'modernising' activities they have actually fallen back into it and find themselves bound ever more tightly to the most fundamental Earthly phenomenon over which they have limited control. For this and other reasons, Latour (2013:77) describes the Anthropocene as the "most decisive philosophical, religious, anthropological and…political concept yet produced as an alternative to the very notions of 'Modern' and 'modernity'". Not only do humans find themselves in a state of ecological vulnerability, but they also find themselves in a state of ontological vulnerability. The former is a harbinger of the latter.

For certain commentators, the Anthropocene is far more than simply a crisis of a particular set of ideas and world-making practices. It is a signifier of the actual end of the world. The philosopher Timothy Morton is one of the most prominent proponents of this thesis, though as noted in section 3.3 the apocalyptic and eschatological nature of the Anthropocene discourse often intimates the same. He states, "Clearly, planet Earth has not exploded. But the concept *world* is no longer operational" (Morton 2013:6).[20] For Morton, the end of the divide

20 Not only does Morton consider the world has ended, but he is specific about when it occurred. He states, "We can be uncannily precise about the date on which the world ended…It was April 1784, when James Watt patented the steam engine, an act that commenced the depositing of carbon in Earth's crust – namely, the inception of humanity as a geophysical force on a planetary scale. Since for something to happen it often needs to happen twice, the world also ended in 1945, in Trinity, New Mexico, where the Manhattan Project tested the Gadget, the first of the atom bombs, and later that year when two nuclear bombs were dropped on Hiroshima and Nagasaki. These events mark the logarithmic increase in the actions of humans as a geophysical force" (Morton 2013:7). It is commonly argued that either of these dates is the best candidate for the beginning of the Anthropocene epoch, something that is much debated by both natural and social scientists, and which has significant political ramifications. For details, see Zalasiewicz, Jan, et al. 2015. "When did the Anthropocene Begin? A Mid-Twentieth Century Boundary Level Is Stratigraphically Optimal." *Quaternary International* 383 (October): 196–203. For a reflexive discussion about why the Anthropocene start date matters and the associated politics, see, Davis, Heather, and Zoe Todd. 2017. "On the Importance of a Date, or, Decolonizing the Anthropocene." *ACME: An International Journal for Critical Geographies* 16 (4): 761–80.

between nature and society was itself enough to mark the end of the world as it was conceived in modernity, or by the 'moderns' (as Latour often describes those still clinging to the conception of modernity, something I will expand upon in the next section).

IMAGE 3.2 James Watt in his Glasgow workshop in 1781 working on the steam engine
Illustrator: Figuier, Louis (c.1870), reproduced from Wikipedia (2022)
For Morton (2013), the invention of the steam engine in 1784 marked the 'first' end of the modern world.

The suggestion that the Anthropocene represents a serious challenge to the 'modern way of life' that carries with it the risk of the collapse of 'the modern world' would seem to be self-evident – climate change and biodiversity loss data alone seem to give credence to this idea. Yet if the biological extinction of *Homo sapiens* over the next century is considered unlikely, as discussed in section 3.4, this leads to the question of what comes after the end of modernity and by extension, the end of the modern world. Would there be another world to come? Logically, yes, there must be, regardless of what it might look like, lest we are all reduced to mere life, living in conditions that we cannot call a world. However, as Colebrook (2019) notes, the crisis of modernity is also characterised by an inability to imagine that its end would not mean the absolute end for us and that it might lead to another, different world. For this reason, she argues that contrary to the suggestion that the Anthropocene discourse is apocalyptic, it is actually counter-apocalyptic. She states,

> The logic of apocalypse ties extinction to redemption, tying ends to the opening of a new world – whether that be an eternal realm beyond the Earth, or an Earth transformed. While apocalypse and the sense of a radically other world 'to come' has perhaps always had some reference to a transformation and redemption of this world, the twenty-first-century imaginary, especially by way of the trope of the Anthropocene, has become intensively counter-apocalyptic. If there is something like 'Anthropos' unified by way of its capacity to generate planetary destruction, then it is this world that becomes the only horizon and only end. (Colebrook 2019:280)

As Colebrook highlights, there is no conception of a future world beyond the existing one. The end of the modern world is a signifier of "the end of the world full stop" (Kingsnorth 2009:19). Furthermore, in an additional reversal of the Judeo-Christian apocalyptic, instead of the end being dramatic and sudden as is commonly imagined, the world will probably fade away little by little instead, offering not so much the risk of sudden death as that of "an aggravating degenerative disease" (Danowski 2016:Ch5). A 'slow violence' (Nixon 2013) of delayed destruction, dispersed across time and space, that will be akin to a 'nuclear winter' (Northcott 2015).

According to Colebrook (2020), the inability to imagine a future world outside of the existing one helps to explain the urgency within the current cultural imaginary towards saving – rather than transforming – the world, something she suggests risks intensifying and entrenching the barbarism that drove us into the environmental crisis in the first place. For Morton (2013) this obsession with saving the world is paradoxically one of the most powerful factors that inhibits a proper engagement with our collective planetary predicament. As he notes, it is perhaps only through allowing the end of the existing world that we can actually save *the* world. On this, Scranton suggests that the greatest challenge we face in the Anthropocene is actually a philosophical one: understanding that 'modern' civilisation is already dead. He states, "The sooner we confront our situation and realise that there is nothing we can do to save ourselves, the sooner we can get down to the difficult task of adapting, with mortal humility, to our new reality" (Scranton 2015:Introduction).

3.6 THE ONTOPOLITICS OF THE ANTHROPOCENE

Discussions and debates about the end of the world bring with them several interrelated ontological and political considerations. These include the notion of 'world' itself, reflection upon whose world is ending, and consideration of the responsible agent driving the end of the world. Opening up these issues reveals complex terrains marked by disagreement and indeterminacy, further confirming the Anthropocene as not just an environmental crisis but also an intriguing philosophical, anthropological, and political puzzle.

The concept of world

Though concepts of world have been part of Western philosophy since the biblical and classical period – there are countless references to *haolam, kósmos, mundus, orbis, universitas* – there has been relatively little scholarly attention to the concept of world itself (Gaston 2013). Researchers take recourse to the word world as if its meaning were self-evident, but as Pina-Cabral (2017) notes, the word remains highly ambiguous, often extending its meaning in a polysemic fashion during the course of any single debate. Today, the more general acceptance of the word world is "what exists" that is, everything. According to the Oxford English Dictionary, however, the main reference is to the planet Earth. The etymological root of the word lies in the Old English word *woruld* meaning "human existence, the affairs of life"; itself derived from the Proto-Germanic *weraldiz*, a combination of the words for "man" (*veraz*; related to Latin *vir*) and "age" (*aldiz*, meaning age, generation), thus implying "the age of man".

Philosophers and anthropologists have debated whether we live in a single unified world, a plurality of different worlds, or indeed whether there is any world at all.[21] For Pina-Cabral (2017), the concept of world wavers in the unstable terrain that lies between the singular and the plural – it is simultaneously one (the Earth, everything) and many (the individual and collective experiences of the Earth within a world-like domain). Law (2015) suggests that one of the salient characteristics of modernity is the constitution of what he terms a 'one-world world'. Such a world sees itself as unitary and universal and the only world to which other worlds must abide or be sentenced to disappearance in the name of the common goods of progress, civilisation, development, and liberal inclusion. This world, according to (Mitchell 2000:xi), has an autocentric picture of itself as the expression of certainty so that "its history has always claimed to be a universal one, in fact the only universal history". Though the 'one-world' metaphysics of the West are powerful, Law suggests they are not as powerful as they imagine themselves to be. They rest on what he describes as a "raggedy set of strategies" that are in the business of repressing difference (Law 2015:10). In opposition to this, the concept of the 'pluriverse' has recently been proposed (Escobar 2016; Mignolo 2018), which is the "decolonial political vision of a world in which many worlds would coexist" (Mignolo 2018:ix). The idea challenges the logic of universal modernity that there is only 'the world' and 'other' worlds exist in relation to 'the world' or are rendered non-existent. The pluriverse is a world in which multiple worldviews, practices and livelihoods co-exist; a world where no one particular way of living shuts down others (Escobar 2012). It interrupts the commitment to one common world (modernity) and instead shifts the focus to the ongoing processes of making many worlds, to "heterogeneous worldlings coming together as a political ecology of practices, negotiating their difficulty of being together in heterogeneity" (De la Cadena 2018:4).

21 "As much as everyday language may expose the porous nature of concepts of world, we must always keep open the possibility that there is no world" (Gaston 2013:Ch6).

Whose world is ending?

The idea that the world is ending only has a determinate meaning and can only be thought of as possible on the condition that one determines at the same time for whom this world that ends is a world, and who is the worldly or 'worlded' being who defines the end (Danowski 2016).

IMAGE 3.3 Artist's illustration of the end of the world
Artist: Shin, Dadu (2020), reproduced from Emergence Magazine, April 24th, 2020

When it is claimed that the 'modern' world is over or is on its way out, as has been discussed, it raises a core question about the subjects of that world. Is every human on the planet part of the modern world, or is it a specific, albeit large, subset of humanity?

Latour famously describes the subjects of modernity as 'Moderns' (Latour 1993), though he is notoriously vague in identifying their particular characteristics, where they are from, and in what period they came into being. In an overview of his anthropological work, Berliner (2013:439) suggests that for Latour, the Moderns are "those who love to think of themselves as part of the 'modern world'". This interpretation aligns with Berman's definition as those who attempt to "become subjects as well as objects of modernisation, to get a grip on the modern world and make themselves at home in it" (Berman 1988:5). Whether there are any humans who sit outside of these broad definitions who are not in some way engaged or aspiring to be engaged with modernity is much debated.[22] As Berliner notes,

> We wonder whether the Moderns are such an exception today. Reading Latour leaves us pensive about the global dissemination of peoples, ideas and forms of life; about Achuar youngsters being educated in large cities; about Indian architects and Aboriginal teachers who are now taking part in the constitution of modernity. (Berliner 2013:444)

As part of attempts to better map the heterogeneity of global societies and their different forms and levels of engagement with modernity, Eisenstadt (2000) proposes the idea of 'multiple modernities' as a means of capturing the myriad ways different cultures partake in the 'modern' world. As critics point out, though, such a view implies that modernity, in its various forms, has attained a normative status globally. For Blaser (2009), the assumption of a single ontological matrix within which all social formations are contained downplays the extent to which the world at its current juncture is beset by ontological conflicts and struggles for what Kilcullen (2015) calls 'competitive control'. Nonetheless, it does not seem controversial to suggest that all societies partake in modernity in one way or another. Indeed, much contemporary anthropological research involving indigenous people, for example, has sought to combat colonial representations of indigenous cultures as being wholly traditional and thereby outside of the modern world. The work of Descola (2013) helps us situate modernity (multiple or otherwise) as one particular ontological formation among others. These ontologies differ from modernity not because, as Euro-modernity would pose it, they lack what modernity has but because they distribute what exists and conceive their constitutive relations in a different way.

22 Gyekye (1997:263), asserts that modernity "has in fact assumed or rather gained a normative status, in that all societies in the world without exception aspire to become modern, to exhibit in their social, cultural and political lives features said to characterize modernity whatever this notion means, or those features are. By virtue of the overwhelming and resilient importance of the notion, Western societies generally, from which the notion is said to have emerged, have become the quintessence of modernity, the mecca to which peoples from non-Western societies go for inspiration and knowledge as to models of thought and action in pursuit of the development of their societies and transition to modernity".

Notwithstanding the importance of discussions about who is or isn't a part of the 'modern' world, and a potential victim of its end, it seems clear that the whole of humanity will in some way be affected by the environmental crisis. Whilst not every human is responsible for bringing about the Anthropocene, all are destined to live in it. According to Zylinska (2017:Ch8), it will, in fact, be a "great leveller" that carries with it a form of "finalist political schadenfreude" in that "the rich will finally be equal with the poor and will all go down the same". We will be unified as a species once more by our common planetary predicament.

Indigenous experience and the extinction of former worlds

Indigenous and decolonial scholars, such as Davis and Todd (2017), Whyte (2017), and Karena (2018) have criticised the discourse on the Anthropocene for its 'one-world' logic and fatalistic tone. They have argued that the idea of a single future 'end of world' and the suggestion that 'we are all in it together' magnifies colonial discourses that treat extinction or extermination as inevitable for indigenous people and other people of colour. It also, they claim, conceals some of the burning social antagonisms of the Anthropocene, including the fact that the world whose end is now being mourned was only possible in the first place because it ended so many other worlds, the impacts of which are still being lived through in the present. As Danowski observes,

> The genocide of Amerindian peoples – the end of the world for them – was the beginning of the modern world for Europe: without the despoiling of the Americas, Europe would have never become more than the backyard of Eurasia, the home continent of civilisations that were much richer than the Europeans during "our" Middle Ages (Byzantium, China, India, the Arab polities). No pillage of the Americas, no capitalism, no Industrial Revolution, thus perhaps no Anthropocene either. (Danowski 2015:Ch7)

And it is not only that the trajectory of the Anthropocene necessitated the erasure of the worlds of many others,[23] it is that the ancestors of these former worlds now exist in a life of 'social death' (Colebrook 2020) in what has been described as a 'post-apocalyptic present' (Lempert 2018). According to Whyte (217:208), the dystopia many indigenous people experience in the present "already sounds a lot like what others in the world dread they will face in the future as climate destabilisation threatens the existence of species and ecosystems".

23 Koch (2019), for example, estimates as many as 56 million out of a total population of 61 million died within a little over a century following the European conquest of the Americas, beginning in 1492. Danowski (2015) identifies this as the biggest demographic catastrophe in history until now, with the possible exception of the Black Death. Lewis and Maslin (2015) suggest that the genocide of the Americas is a strong candidate for the actual commencement of the Anthropocene, centred on what they term the "Orbis hypothesis" – a global drop in CO_2 level brought about by the massive depopulation of the American landmass and widespread reforestation of previously populated landscapes.

IMAGE 3.4 Hanging, burning, and clubbing of Indians by Spanish soldiers
Illustrator: De Bry, Theodor (c.1598), reproduced from Wikipedia (2022)
"[The Spaniards] built a long gibbet, low enough for the toes to touch the ground and prevent strangling and hanged thirteen [natives] at a time in honour of Christ Our Saviour and the twelve Apostles…Then, straw was wrapped around their torn bodies, and they were burned alive" (De las Casas 1598, as quoted in Stannard 1992:148).

That many indigenous people have managed to endure suggests they may have something to teach us about the world ending. For Chandler (2018), the ability to even survive should be seen as a lesson in resilience and sustainability that Western subjects might take on board during attempts to work through the world-ending Anthropocene epoch. The fact that colonised people have endured the end of the world – or indeed repeated ends of worlds – is a reminder that even the most unthinkable cataclysmic events are not necessarily terminal. As Yusoff (2019:Ch1) states, the end of the world for some can sometimes be the prerequisite for the possibility of imagining "living and breathing again" for others.

Responsibility for the Anthropocene (and the end of the world)

Reflections on the Anthropocene and the possible end of the world inevitably brings with it critical consideration about the responsible agent driving us towards the end times.

Are all the inhabitants of the planet culpable for the environmental crisis, or is it the indeterminate group loosely known as the ‘moderns’? The Anthropocene has received intensive criticism from humanities scholars for its highly generalised invocation of the single-subject figure of ‘Anthropos’, or the ‘Human’, or ‘We’ as the solitary author of its effects, something Cohen (2016) suggests overrides a vast amount of critical work. Amongst many scientists, there appears to be an almost settled premise that ‘global humanity’ has driven us into the Anthropocene, rupturing the Earth System, and profoundly shifting the direction of human and nonhuman life upon the planet.[24] Beneath such sweeping generalisations, complexities of race, ethnicity, gender, and class are often ignored, as is the fact that the destruction wrought has mostly been caused by a very small percentage of wealthy humans.[25] According to Luke (2018), the Anthropocene concept reduces billions of divergent human-caused events to one large-scale, unified set of nonhuman effects, eliding the fact that agency and responsibility for the impacts are unequally distributed, both historically and contemporaneously.

Assigning precise responsibility, though, is far more complex than many commentators are prepared to admit. As Danowski (2016) notes, in the context of the climate crisis at least, the line separating victims and culprits is clear from a collective or societal viewpoint,[26] but much harder to trace from the point of view of individual action. This is because today many of us are victims and culprits ‘all at once’ in each action we engage in, at the push of every button, with each portion of food we swallow, and with each vehicle journey we take. However, she also emphasises that it is important not to lose sight of the difference between assemblages that are thoroughly invested in the practices that have generated the Anthropocene and those who are more or less forcefully dragged along. There is a world of difference between McDonald’s and the teenager conditioned into consuming junk food, or Monsanto and the small farmer obliged to spray his genetically modified corn with glyphosate.

Without denying historical patterns, Hamilton (2017) believes there is a pragmatic reason for attaching the new epoch to an undifferentiated ‘Anthropos’. Focused on climate change (but with a recognition the same may eventually apply to other contributions to Earth System disturbance, such as biodiversity loss), he suggests that by the middle of the century

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24 See, for example, Waters et al. (2016). The twenty-two authors of this paper draw clear lines in the sand in attributing these changes to global humanity.

25 For details about the erasure of race and ethnicity, see Luke (2018) and Yusoff (2019). For details about the omission of gender, see Haraway (2016) and Grusin (2017). For critiques of the undifferentiated nature of the Anthropocene discourse and discussions around historical responsibility, see Malm and Hornborg (2014) and Moore, J.W., ed (2016).

26 See, for example, Evans, Simon. 2021. “Analysis: Which Countries Are Historically Responsible for Climate Change?” *Carbon Brief*, October 5, 2021. https://www.carbonbrief.org/analysis-which-countries-are-historically-responsible-for-climate-change

the Global South[27] will be responsible, both contemporaneously and historically, for much more damage to the global climate system than the North as it copies the northern model of environmental harm in the pursuit of poverty-alleviation and affluence. By 2050 at the latest, the objections to 'Anthropos' will seem very dated. He states, "if the Anthropocene was a Eurocentric idea when it was coined, it is now Sino-Americo-Eurocentric, and in a decade or two it will be Indo-Sino-Americo-Eurocentric" (Hamilton 2017:Ch1). This does not, I suggest, negate Danowski's point about levels and degrees of responsibility, which is applicable across most nations and societies, but it does indicate that debates about 'liability' for the Anthropocene, including associated issues of social justice, are destined to become more complex and are unlikely to be resolved any time soon.

3.7 CONCLUSION

Humans have never been more potent nor exercised such dominion over nature. Yet because of this, we are simultaneously exposed to the power of natural forces and the vicissitudes of the Earth in a way we have never experienced previously over the entirety of our 200-300 kyr history. Anthropogenically driven climate change, biodiversity loss, pollution, and ocean acidification, amongst many others, have created unprecedented levels of environmental risk and ecological vulnerability. As discussed in section 3.4, this may result in the biological disappearance of humans from the planet over the next century, though it is considered much more likely that we will survive. However, it seems apparent that we are heading into a future in which the current majority world – the world of 'modernity' – and the taken-for-granted practices, projects, and identities associated with it face collapse and perhaps disappearance. The ecological vulnerability we face in the Anthropocene is therefore, I suggest, a harbinger of our ontological vulnerability.

Visions of civilisation's end and the 'end of the world' are nothing new. The apocalyptic tropes that underpin the Anthropocene narrative (and as I have noted, environmentalism since its inception) have been recurring throughout Western and non-Western cultural history – from pre-modern religious texts such as the *Epic of Gilgamesh*, the *Book of Daniel*, and the *Book of Revelation* to contemporary productions such as Cormac McCarthy's dystopian novel, *The Road*, TV series such as *The Walking Dead*, and video games such as *Death Stranding*.

Though often overlooked within popular cultural concerns about 'the end times', we know that the world has already ended, over and over, for countless peoples and epochs. Just as Zalasiewicz reminds us that there is not one Earth but rather "different Earths that have succeeded each other in time" (as cited in Hamilton 2014:6), so too can we see there have been multiple worlds and ways of life that have come and gone. The world of Palaeolithic

27 The phrase "Global South" refers broadly to the regions of Latin America, Asia, Africa, and Oceania. It is one of a family of terms, including "Third World" and "Periphery," that denote regions outside Europe and North America, mostly (though not all) low-income and often politically or culturally marginalised (Dados 2012).

IMAGE 3.5 Death Stranding
Source: Kojima Productions (2021)
Hideo Kojima's epic video game, *Death Stranding*, confronts the aftermath of the sixth extinction caused by nuclear war and the 'rebuilding' of America.

hunter-gatherers ended with the emergence of cities and agriculture. The world of Tang-dynasty China ended with the rise of powerful eunuchs and peasant revolt. So too did the preliterate world of the eastern Mediterranean, brought to life in Homer's Iliad, as literacy transformed Greek conceptions of being. Countless worlds were also destroyed through the Columbian Exchange and the conquest of the Americas, many completely erased from memory. These worlds are gone in an absolute sense, though they live on, absorbed into, and remembered by the world we live in today, a world that, as I have described, may now be reaching its own end.

All worlds are susceptible to their eventual collapse. The way of life they sustain can become impossible, ceasing to make sense and matter. This, perhaps, is what we 'moderns' face as denizens in a dawning Anthropocene. Yet history also tells us that the end of a world does not mean the end of everything. Nor, as contemporary indigenous societies evidence, does it preclude the possibility of the continued existence of the descendants of former worlds from living and breathing again. Ends are also beginnings and can be transformative. As Scranton (2020) notes, "if we take a more cosmic point of view, the end of the world could mean merely that "the world" – our mutually constituted sense of the collective now – is changing into something else, perhaps no more or no less than a new world, a new now, a different collective sense of human life".

The crisis of modernity is not only characterised by the arrival of the Anthropocene and the possibility it might be world ending. It is also characterised by an inability to imagine that the end of the modern world would not mean the absolute end for us and that it might lead to another, different world. As Colebrook (2020) suggests, this failure of imagination is what drives the urgency toward saving rather than transforming the existing world. Not only does this inhibit a full engagement with the environmental crisis, but it also, she believes, risks compounding the barbarism that drove us into it in the first place. I argue that this barrier risks humans becoming ontologically 'locked in', stuck between a precarious present and the permanent sense of crisis, and the fear of a lamentable future as planetary conditions deteriorate over time and become increasingly inhospitable to human life. I also suggest that if we allow ourselves to become too attached to the existing world and its lifeforms, it risks creating aversion towards a future world and its lifeforms. I will explore this further in the next chapter, where I will identify ways of reconceptualising the sixth extinction not solely as a time of crisis and loss, which it undoubtedly is, but also as a time of emergent possibility, where hope is still present, and the future is more open than is popularly imagined.

CHAPTER 4

INHABITING THE SIXTH EXTINCTION

4.1 INTRODUCTION

The previous chapter concluded by suggesting that the obsession with 'saving the modern world', and the reluctance to accept that it may soon end or is perhaps already over, creates a barrier inhibiting full engagement with the 'new world' conditions of the Anthropocene. I argued that this barrier risks humans becoming ontologically 'locked in', stuck between a precarious present with its permanent sense of crisis, and the fear of a lamentable future as planetary conditions deteriorate over time and become increasingly inhospitable to human life. I also suggested that if we allow ourselves to become too attached to the existing world and its lifeforms, it risks creating aversion towards a future world and its lifeforms.

As an alternative to these ultimately disabling narratives, this chapter will consider how it is possible to engage with the biological and ecological conditions of the Anthropocene and the sixth extinction to imagine a world that extends beyond simply crisis and loss. Whilst it is undeniable that life is becoming increasingly deadly for many of the planet's lifeforms, as I will explain, it is not the case that all are diminishing. In fact, some are thriving and taking advantage of the human-made opportunities now available to them. Not only is this offsetting some of the detrimental effects of human activities in real-time, but over the long future, it has the potential to result in greater species diversity than presently exists.

That there is little formal recognition and awareness of this, despite its grounding in empirical science, speaks to the points of my opening paragraph, above. It suggests both a reluctance to engage with the 'new world' conditions of the Anthropocene and a refusal or inability to envision the possibility of another world to come. It also, as I will discuss, serves to illustrate how long-standing preconceptions about nature, including the common belief that it somehow lacks resilience and dynamism, and also what is judged to constitute 'good' or 'bad' nature, strongly influences perceptions of the biodiversity crisis. They also compound the general sense of anxiety about the present and, by extension, uncertainty toward the future.

The overall intention of this chapter, then, is to try and rearticulate the biodiversity crisis – which I use here as a broad term that fully encompasses but is not limited to the sixth extinction – as not simply a time of catastrophe and loss, which it surely is, but also a time of emergent possibility where the future is more open than is popularly imagined. By utilising ideas from resilience theory, exploring and critiquing some of the common perceptions about nature, and investigating scientific data about species movement and configurations in the Anthropocene, I will offer, in part at least, a counter-vision to the dominant loss narrative common within much of the environmental discourse. I ultimately suggest that if humanity wants to imagine a more hopeful future, the sixth extinction needs to be actively 'inhabited' with acknowledgement of the unintended biological opportunities emanating from it. To do otherwise, I suggest, would fail to recognise the inherent dynamism of life on the planet and its capacity to respond to whatever challenges and opportunities it encounters.

The chapter is effectively composed of two parts. Part 1, covering sections 4.2-4.4, begins with a brief exploration of the crisis narrative within the dominant environmental discourse. I will describe how human relations with the natural world are invariably framed as tragic, with the future reduced almost entirely to loss. The openness, contingency, and multiple projections about other future possibilities are closed off in favour of a singular, loss-based deterministic view. As an alternative to this line of thinking, I will explore Human Ecologist Stephanie Wakefield's 'Anthropocene back loop' proposition. This experimental idea, derived from ecological resilience theory, focuses on the creative possibilities emanating from contemporary environmental stresses. Via what is termed the 'adaptive cycle heuristic',[1] it provides the opportunity to perceive the Anthropocene as not simply a time of crisis but "a scrambling where possibility is present, and the future is more open than typically imagined" (Wakefield 2017:6). It also challenges us to view the Anthropocene as not something we should instinctively push against but also as a time of potential that we can choose to dwell within.

Adopting Wakefield's proposition, I explore whether it is possible to take her experimental 'back loop' idea and utilise it to think through species loss and the sixth extinction. Is it possible to acknowledge the reality of the biodiversity crisis yet move beyond the sense of loss, mourning, and melancholia towards a more affirmative vision of biological futures? Are there unintended consequences emanating from the biodiversity crisis that may benefit rather than diminish planetary life? Humans, through their multifarious activities, are commonly perceived to be damaging the natural world. The possibility their actions may result in something other than this is mostly unexplored and unimagined.

Central to this, I suggest, is the common belief that nature is a passive object unable to react to the anthropogenic stresses placed upon it. Such a perception, I will explain, has a long history in Western thought that came to a head during the Enlightenment when nature's dynamism and creativity were killed off and became "deanimated" (Latour 2017). Rejecting the Enlightenment belief in a deanimated nature aligns with ecological resilience

1 The adaptive cycle heuristic originated out of comparative studies of localised ecosystem dynamics in boreal forests in British Columbia and was originally devised as a tool to think through the creative possibilities emanating out of localised biological and ecological stresses. The heuristic is now used and customised by many thinkers who bring their own uses and emphases to it. It will be discussed further in section 4.3.

theory and the cyclical ideas of the adaptive cycle. It also prompts us to consider whether there will be any upsides to the downsides of human impacts upon the planet. I suggest there will be, and Part 2 of this chapter, covering sections 4.5-4.8, will explore this further. I will describe how the human-mediated translocation of species around the planet over the past 500 years or so, identified by some as a key signature of the Anthropocene, has not only resulted in almost all countries, states, and islands becoming more biologically diverse than they have ever been (Thomas 2013) but has also effectively reconnected the planet's biota for the first time since the breakup of the Pangean supercontinent 175 million years ago. This has led to the formation of what McKinney (2005) describes as the 'New Pangea', a metaphor for the widespread biological connections of the modern world. These connections have led to a preponderance of so-called 'novel' ecosystems – never before encountered species assemblages that now occupy most of the Earth's terrestrial land surface (Miller 2016). This has changed the evolutionary trajectory of countless species, potentially stimulating them to diversify and speciate en masse at a rate that may eventually match or exceed anything previously experienced over Earth history. The stage has been set, it has been suggested, for a major genesis of new life over the next few million years.

Such a view presents a challenge to the prevalent crisis narrative, particularly projections of imminent planetary collapse or, as discussed in the previous chapter, the 'end of the world'. It also leads to a confrontation with the concept of nature and what is considered 'natural', something that will be discussed in section 4.8. The replacement of 'natural' ecosystems with 'novel' ones, and 'native' species with 'non-natives' present significant challenges to our conceptions of the natural world and the human place within it. They also stimulate several open questions that take us to the heart of human relations with the natural world. Are humans part of nature, or do they somehow reside outside it? Are anthropogenic environments unnatural? And regardless of whether they are, if they offer significant conservation value, should they be appreciated any less than historical environments or those with minimal human disturbance?

I conclude by suggesting that as per Wakefield's proposal to 'inhabit the Anthropocene back loop', identifying it as a time of great possibility, natural scientists should also strive to recognise the potential of what I term the 'sixth extinction back loop' for the same reason. Rather than shying away from the novel ecologies and species arrangements of the present, as many conservationists and extinction biologists do, and ignoring the potential for elevated speciation rates both now and in the future, they should be recognised as reflective of the dynamism of life and its capacity to persist and renew. I suggest environment researchers should acknowledge that these new and novel arrangements likely offer the best opportunity for many species lineages to persist in the longer term and are of great conservation value.

None of this is to underplay the problems of anthropogenic biodiversity loss nor imply there should be any weakening of preventative efforts towards further losses. It does, though, suggest that if humans want to see the future as simply more than a degraded version of the present, there may be little choice but to accept the environments humans have created and the accompanying species configurations, rather than objecting to them because they do not fit the ideal of what nature should look like. In short, I suggest we need to inhabit the 'sixth extinction back loop' as a part of any solution to survive in the long future.

4.2 REDUCING THE FUTURE TO LOSS

The dominant narrative within the discourse around contemporary species extinctions and the prevalent environmental discourse is fundamentally one of loss and catastrophe where human relations with the natural world are ultimately framed as tragic (Heise 2010; Mitchell 2016). This is evident in material from the natural science realm with the predictions of big species losses (Dirzo 2014), environmental conservation, which often evokes feelings of elegy and tragedy about the state of the natural world (Cafaro 2014), and the eschatological nature of much of the Anthropocene discourse where there is an underlying sense of hopelessness about the future with biological life positioned as under heightened threat (Dürbek 2019). These pessimistic narratives offer both humans and non-humans alike little chance of escaping their inevitable destiny brought about by environmental decline. Lovelock (2007:4) offers a vivid melodrama of such a pre-determined fate. We are, he states, "travelling on a rocky path to Stone Age existence on an ailing planet, one where few if any of us survive the wreckage of our once biodiverse Earth".

Such gloomy predictions are often driven by big-picture estimates and projections about biodiversity loss and climate change, two of the most powerful analytics to envisage the future of life and conditions upon the planet. These are normally derived from complex simulation models or by the amalgamation of datasets to make strong universalist claims about the future. I have already described widely cited examples of this in chapter 1 where both Ceballos (2015) and Barnosky (2011) assess modern rates of vertebrate extinctions and use them as proxies for the whole of life to make declarations about whether we are in the sixth extinction or not. This despite vertebrates comprising less than 4% of all known species in the Catalogue of Life (Roskov 2019). Other notable examples include Thomas (2011) who combines IPCC data with species-area calculations of biodiversity loss within tropical forests to project as much as a 37% global species reduction by 2050 due to climate change. And Stern (2006) who also utilises IPCC data to estimate 185 million human deaths by century's end in sub-Saharan Africa, again attributable to climate change.

Hulme (2011) observes that such methodological approaches and predictions are now dominant in the projection of environmental futures and hold an almost vice-like discursive power. He criticises them as reductionist,[2] not because he believes the predictions will turn

2 Reductionism is an approach to understanding the nature of complex entities or relationships by reducing them either to the interaction of their parts or else to simpler or more fundamental entities or relationships (Hulme 2011:249).

out to be wrong, but because, "the openness, contingency, and multiple possibilities of the future are closed off as projections assert their influence over everything from ecology, evolution, and human behaviours" (Hulme 2011:249). In other words, they offer a singular view of the future where other emergent possibilities are foreclosed or diminished. The future, according to these perspectives, has been over-determined, reduced entirely to loss. This, he suggests, is nurtured by elements of Western cultural nihilism that promote pathologies of vulnerability, fatalism, and fear regarding the state of humanity and nature.

Theriault (2020:180) argues the need to resist such pessimistic, black and white accounts or projections of decline. Referring to biodiversity loss, he states, "it is necessary to nurture alternative concepts and practices…that recognise the capacity of life forms and worlds to resist the violence that threatens them and that respect refusals of subjugation and erasure". This is not to deny or underplay the dire warnings about species extinctions, but rather to try to think beyond the hegemonic rhetoric of loss and catastrophe towards other potentialities. The epistemological pathways offered by the dominant discourse on the environmental crisis are important for generating reflection and action about the past, present, and future. But they also risk creating what Masco (2017:66) refers to as a "crisis-paralysis circuit" where the constant shadow of catastrophe generates a permanent sense of crisis around an ever-precarious present. To counter this, we need other complementary ways of thinking that keep in mind the narratives of decline but which also recognise the "ontological anarchism" of the Anthropocene with all its "meta-modes of existence and being" (Viveiros de Castro 2019:S296).

As discussed in the previous chapter, debates and discussions about the Anthropocene seemingly force upon us an image of the future where humanity is offered a seemingly impossible choice between either wallowing in despair or risk-laden technocratic solutions, such as climatic geoengineering, wherein our scrambling to survive on a degraded Earth we endlessly manage a world falling apart. But is it possible to forego such thinking to try to envision a world that is otherwise? Are we able to acknowledge the reality of species extinctions, increasing CO_2 levels, and other elements of the environmental crisis whilst still retaining hope and possibility? Over the 3.4 billion years of life on the planet, it is accepted that life has been continually subjected to catastrophic forces. Yet, to date, it has always endured and surged with even greater force. Crisis for some forms of life has invariably resulted in opportunities for others – ends have always simultaneously been beginnings. Reminding ourselves of this is an important step to counter the prevalent narratives of loss. Possibility for the ongoingness of life is always present, even within "blasted landscapes" (Kirskey 2014).

For Donna Haraway, the possibility for the future hinges on what she terms, "staying with the trouble". She states, "staying with the trouble requires learning to be truly present, not as a vanishing pivot between awful or Edenic pasts and apocalyptic or salvific futures, but as mortal critters entwined in myriad unfinished configurations of places, times, matters, meanings". This to avoid succumbing to "abstract futurism and its effects of sublime despair and its politics of sublime indifference" (Haraway 2016:Introduction). In other words, learning how to live and die as mortal beings with the non-human world on what we recognise is a damaged Earth will prove more conducive to the kind of thinking that might provide the means to build more liveable futures. For Scranton (2015), and his call of "learning to die in the Anthropocene", optimism for the future relies upon a radical Buddhist rejection of hope. In his opinion, only by acknowledging that we are in effect already dead, and that Western civilisation is also dead can we truly learn how to live. Hope, for Scranton, is attained not by promoting an explicitly hopeful message, but rather by denying hope. Hope, therefore, lies on the other side of despair.

4.3 THE ANTHROPOCENE BACK LOOP

What both Haraway and Scranton, in their distinctive ways, are suggesting is that we need a transformation in our thinking so we may face the reality of the planetary situation and indeed ourselves, anew. Only by doing this will we have any chance of inhabiting the future positively, to the overall benefit of humans and non-humans alike. In the same spirit, Wakefield suggests an engagement with ecologist C.S. Holling's resilience concept offers a tangible way of imagining and inhabiting the Anthropocene, enabling us to re-conceptualise it as neither a crisis to avoid or manage nor a world of "ruins" (Tsing 2015) but rather, "a time of dislocation and possibility that calls to be inhabited via creative and situated experimentation" (Wakefield 2017:2). Via a critical reading of the Anthropocene discourse combined with resilience theory's adaptive cycle heuristic, she locates the possibility of new forms of life in its phase of release and reorganisation: the back loop.

The back loop is a relatively new and little-studied concept. Until the 1970s, ecologists viewed ecosystems as progressing from an initial growth or exploitation phase to a final phase of conservation or stability. The classic example is a forest: the first phase is dominated by fast-growing pioneer species that colonise and exploit a fresh base of abundant resources. Over time, they are replaced by more specialised organisms, greater attuned to the systems and nutrients. This results in a mature forest, a 'climax' community where everything – sunlight, water, biomass is in balance (Gunderson and Holling 2001). The climax phase was viewed as the ideal endpoint, where a system's steady state was made up of the organisms best adapted to the environment. For most of ecology's history, ecological management was designed around conserving and managing ecosystems in this stage. In other words, it was thought the 'front loop' was all there was to life.

The model underwent revision in 1973 when Holling modified this idea, leading to the new field of resilience theory. Systems, he argued, do not remain in a single steady state. Rather, they regularly experience phases of release and reorganisation, collapse, creative destruction, and renewal. He proposed that it was necessary to add another loop – the so-called 'back loop'. For ecologists, back loops occur due to sudden or extreme events – a forest fire, a flood, disease outbreak. In the release phase, energies and elements captured in the conservation phase are set free. This is the time when "unexpected events happen…The accumulated resources are disassembled, broken down, left uncontrolled" (Holling 2004:3). It's as if "somebody threw the forest's remaining plants, animals, nutrients, energy flows into a gigantic mixing bowl and stirred" (Homer-Dixon 2006:228). The back loop is therefore a time of great possibility where the previous forest may be re-established via its remaining seed banks, or novel or unexpected synergies between extant and invasive species may eventually give rise to new arrangements. Holling (2001) summarised these ideas in a model he named 'the adaptive cycle'.

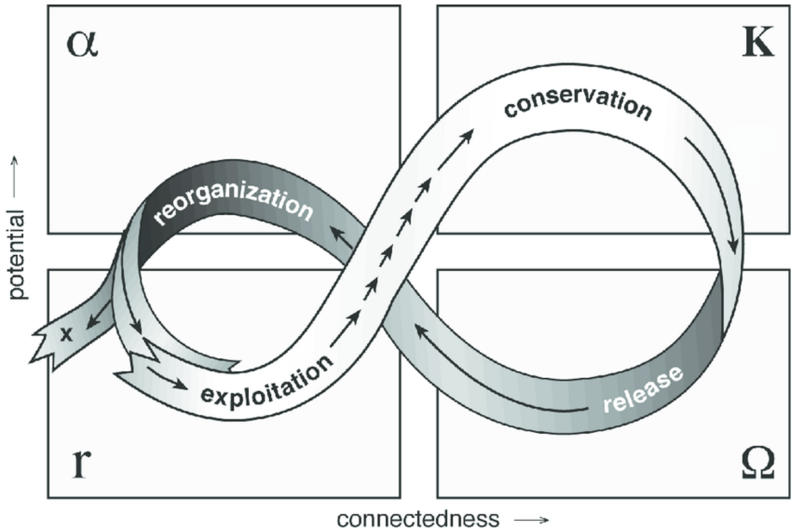

DIAGRAM 4.1 The adaptive cycle
Source: Gunderson & Holling (2001)
Exploitation (r) to conservation (K) represents the 'front loop,' while release (Ω) to reorganisation (α) depicts the 'back loop'.

The adaptive cycle heuristic and its extension to panarchy[3] (nested adaptive cycles) is used and customised by many thinkers who bring their own uses and emphases to it. The basic concept though is that all complex systems – forests, swamps, even companies – cycle through a front loop of growth and stability and a back loop of release and reorganisation. Resilience practitioners, such as conservation scientists and restoration ecologists, implicitly advocate the governance or management of the back loop phase to prevent the loss of a system's identity with the intention of returning to the front loop phase (i.e., the familiar, 'stable' state of the ecosystem or particular landscape). However, this overlooks the potential of the back loop as a moment of reorganisation where different arrangements can emerge, new possibilities are worked out, and novel systems can materialise.

Given that most empirical studies using the adaptive cycle and the back loop have been at local or regional scales, Holling asks whether it might be possible to utilise the heuristic to research the "deep back loop" (Holling 2004:5) of global and international environmental

3 Nested adaptive cycles with bi-directional cross-scale feedback are called a panarchy. The core hypothesis of panarchy is that key processes that structure complex systems occur at different ranges of spatial and temporal scales, often separated by orders of magnitude. For further details, see https://www.resalliance.org/panarchy

change. Taking up this idea, Wakefield (2017; 2020) explores whether the methodology of the adaptive cycle can be used as a lens through which to think through the Anthropocene. In her formulation, the Anthropocene can also be considered to have front and back loop phases. The front loop, she believes, is marked by the modern liberal subject and the spread of modernity, centred around the core ideas of the dualism of nature and society, the notion of objective science, and the assumption of linear control and continual progress, as discussed in the previous chapter. With human affairs in the foreground in the front loop, the literal ground (the Earth) could be forgotten or was at best the backdrop to the human drama.

As I have already described, the arrival of the Anthropocene is said to destabilise these underpinnings and, as such, the guiding principles of the modern way of life are no longer considered tenable. Such a destabilisation, Wakefield proposes, marks the 'Anthropocene back loop' – something that provides a name for the liberal way of life as one finds it today: a sinking ship increasingly taking water from all sides (Wakefield 2020). The claims of human mastery of the world have now evaporated and are dominated by uncertainty in the face of the "rifted body of the Earth" (Clark 2020) which as neither friend nor ground for human activities, now appears as a volatile, irrepressible force. She states,

> In short, one thing would seem clear: we are not in the front loop anymore. The ties that bound – the feedbacks that wove? – the Anthropocene stability domain are coming undone. If the front loop was the 'safe operating space' of the Anthropocene – here understood not only as a 'geo' but also a 'geosocial formation' built on a transcendent *terra firme* of thought and action, however illusory that may have been – this complex, nonlinear 'post-truth' world of fragmentation, fracture, dissolution, and transfiguration is what I propose we call the Anthropocene back loop. The back loop is our present, the moment of the naming of the Anthropocene (as a failure), in which the past (front loop) has not disappeared, like points trailing behind on a line, but is erupting in unpredictable ways in the present. (Wakefield 2017:6)

In Wakefield's experimental formulation, viewing the Anthropocene through the adaptive cycle lens and perceiving the anthropogenic planetary ruptures as the back loop has several benefits. Chief amongst them is the capacity to see the Anthropocene not as a tragic end or world of ruins, but a scrambling, "where possibility is present, and the future is more open than is typically imagined" (Wakefield 2017:6). In other words, not just as a time of crisis (which for many lifeforms on the planet it surely is), but also a time of great potential. Perceiving the Anthropocene this way requires pushing the boundaries of resilience thinking, especially the potential for transformation and rebirth at the heart of Holling's foundational heuristic.[4]

4 Wakefield states, "Thus it bears noting here that while I am borrowing the back loop concept from resilience thinkers, I do not import their other epistemological or governmental assumptions with it. Such I will argue is a useful ethos for living in a back loop, the ability to freely make use of concepts and tools" (Wakefield 2020:146).

Originally developed by Holling as a way of managing the adaptive ecosystems described in his field research, resilience[5] has now become the dominant institutional response to the Anthropocene through either delaying or governing it (Chandler 2020). In contrast to front loop modes of management that try to maintain a perpetual stability state, resilience is a form of back loop management that seeks to create and define 'safe operating spaces' within systems that can absorb and manage disturbance, rather than eliminate it (Wakefield 2020). A recent and now famous resilience proposition on a planetary scale has been made that seeks to identify and govern the limits of the Holocene's key Earth processes. Developed by the Stockholm Resilience Centre and termed the 'Planetary Boundaries Framework' (Steffan 2015), nine 'planetary boundaries' have been suggested (diagram 4.2), representing specific thresholds of climate change, biosphere integrity, ocean acidification, amongst others, that collectively delimit a 'safe operating space for humanity'. Transgressing any of these boundaries is expected to lead to an increased risk to aspects of human wellbeing or would undermine the resilience of the Earth System as a whole. As can be seen below, four of the nine boundaries, marked in yellow, are deemed to have been passed already hence, the stability of the Earth System is already under threat. The express aim of the framework is to monitor the nine identified boundaries to try and ensure none are encroached upon by human actions. Those that are will somehow need to be managed back inside their defined 'safe operating space' (the areas shaded green). This to maintain the integrity and stability of the system and ultimately ensure ongoing global societal development.

For Wakefield and other critical scholars (e.g., Chandler et al. 2020), the dedication to staying in or trying to return to the front loop of the Holocene, as the Planetary Boundaries Framework suggests, is largely disabling, as survival is tethered to maintaining the existing economic, social, and power relations that drove humanity into the Anthropocene in the first place. Furthermore, the future risks becoming one of endless crisis management, with a continual crossing back and forth across the various boundaries to maintain the integrity of the existing (now failed) system. Wakefield, though, believes another possibility exists: rather than trying to permanently navigate or manage ourselves out of the Anthropocene back loop back into the front loop, we can choose to inhabit it, not fight it, and open ourselves to its inherent possibilities. Choosing to inhabit, rather than navigate, necessitates simultaneously recognising its potential where the future is not foreclosed, but also acknowledging that we face a time of great uncertainty with humanity entering bioclimatic regimes that are completely unknown to us. Whether we're prepared or able to face these regimes is another matter, tethered as we are to modes of thinking from the front loop. But endeavouring to read the Anthropocene through the lens of the adaptive cycle heuristic and the

5 Whilst there is no agreed definition, resilience's general idea relates to how systems of different kinds react to shocks and, though sometimes changing to certain degrees, uphold their overall character. For further details about the various approaches across disciplines, see Chandler, David, and Jon Coaffee, eds. 2017. *The Routledge Handbook of International Resilience*. Routledge.

back loop suggests that now is a time when we can let go and open ourselves to new possibilities, including fresh foundations for thought and action. As Wakefield (2020:135) states, "Inhabiting the back loop entails seeing our environments as open and rearranging, but also rich in their own right and capable of rearranging us as well".

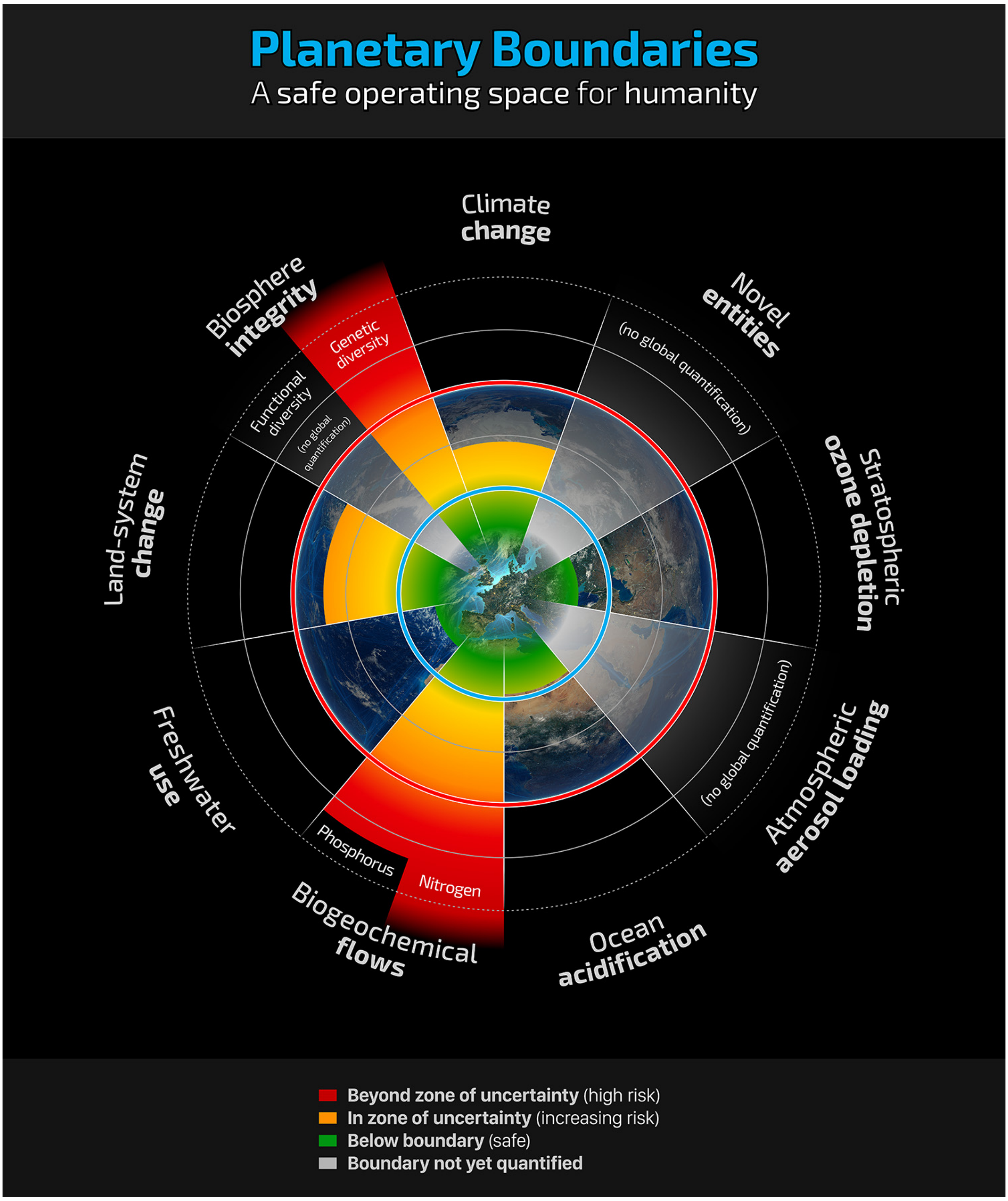

DIAGRAM 4.2 The planetary boundaries
Source: Steffen (2015)
Green is the safe operating space, with the thick red line representing the planetary boundary; yellow is a zone of uncertainty (increasing risk), and red is beyond the zone of uncertainty (high risk). The processes that researchers have not yet quantified are in grey.

Wakefield's experimental proposition of staying in the back loop adapts and pushes the boundary of resilience theory in an attempt to counter the pessimism of the dominant eco-catastrophist discourse of the Anthropocene, as described in the previous chapter, that sees the future as inevitably diminished or foreclosed. Her message can be read hopefully in that within the crisis of the present, she also sees future possibilities, even if we cannot identify what they are. She deploys what philosopher Jonathan Lear terms 'radical hope' (Lear 2006) – a hope that is directed towards future goodness that transcends the current capacity for humans to identify what it is. The question of hope is bound to the question of how to live, the answer to which will only reveal itself in real-time via situated and ongoing experimentation. To an extent, Wakefield's proposition aligns with Haraway in that she also believes we need to 'stay within the trouble', or in her framing, within the 'Anthropocene back loop'. Also, as with Scranton, the rebirth and salvation of humanity are contingent upon acknowledging that our old way of life is dead. There is no returning to the Holocene and the way of life that drove us into the Anthropocene in the first place. Accepting that what we once had or believed is now lost is a key part of the journey to renewal.

Embracing Wakefield's experimental approach to the adaptive cycle, is it possible to take her idea of inhabiting the Anthropocene back loop and somehow connect it to thinking around species loss and the sixth extinction? Are we able to imagine a back loop phase to the human impacts upon biodiversity that move beyond degradation and loss, something we might experimentally term 'the sixth extinction back loop'? Are there any possibilities that flow from the environmental crisis that might benefit planetary life? If we're living through the sixth extinction, is there a way to explore if there is an evolutionary yang to the yin of human impacts? Or is the situation only about loss and destruction? Recall that for palaeontologists and evolutionary biologists, mass extinctions are creative destructive events that eventually lead to species formations exceeding the original diversity. They free ecological space, which leads to speciation, they relax natural selection allowing recoveries, and they open niches for adaptive radiations. They have been key components in the evolution of complex life, which is why from the start, the leading mass extinction theorists such as Raup, Sepkoski, and Jablonski were explicit in emphasising that from an evolutionary perspective, the consequences of mass extinctions are important and even exciting.

Read through the lens of the adaptive cycle, we might say that mass extinctions originate within the front loop for reasons that are mostly unclear[6] and the back loop is the species reorganisation and recovery phase where new and sometimes radical evolutionary trajectories emerge, and species numbers eventually recover. If we try to explore this experimental theorising, relative to contemporary biodiversity loss, where might it take our thinking? As stated at the beginning of this chapter and as evidenced from the material reviewed in chapters 1 and 3, a central component of virtually all accounts of the sixth extinction is the

6 Historically, the precise causes of prior mass extinctions are little understood. See chapter 1, section 1.2.

idea of unremitting loss. Humans, through their multifarious activities, are deemed to be disturbing the natural world, and this is driving the disappearance of species and animal populations worldwide. Extinction rates are judged to be at least hundreds of times above background rates (De Vos 2014) and wild animal populations are crashing (WWF 2020). The possibility that human activities might result in something other than biodiversity loss is rarely considered by scientists and, for the most part, remains either unexplored or marginalised (Briggs 2017). As was discussed in chapter 2, prior to the 1980s and the first empirical evidence supporting the occurrence of mass extinctions, species loss was generally not researched outside of evolutionary theory. Until this point, speciation and extinction were studied together as part of an integrated whole – natural selection – and were rarely considered separately. With the discovery of mass extinctions came the understanding that species could go extinct for non-evolutionary reasons – bad luck rather than bad genes, to paraphrase Raup (1991). From the early 1980s, therefore, I suggest there has been a complete reversal, and it is now rare for scientists to consider extinction *inside* of evolutionary process. In other words, the speciation element of life has effectively been discounted. Echoing Hulme (2011), we could say that the situation has been 'over-determined' – extinction, and its position as a component part of evolutionary processes has been reduced purely to loss. Viewed through the lens of Holling's adaptive cycle heuristic, the back loop release (Ω) and reorganisation (α) phases have been excluded. It is assumed that there is effectively biodiversity loss without biodiversity recovery, something that has never occurred over the long history of life on Earth.

4.4 NATURE IN THE ACTIVE VOICE

Inherent within the view of nature from much of the environmental discourse is the idea that it is static, unresponsive, inert, fragile, and ultimately on the point of collapse. It is considered to lack resilience, unable to react to the anthropogenically-driven forces bearing down upon it. This manifests strongly within extinction discussions where commentators have gone as far as suggesting that if too much biodiversity is lost then 'spaceship Earth' may fall apart (Ehrlich 1998), life as a whole may be at risk (Ceballos 2016) and because of climate change, large parts of the Earth may be rendered uninhabitable and inhospitable to life (Wallace-Wells 2020). But as Thomas (2020) points out, though life is clearly being impacted by anthropogenic activities, the foundational processes are not. He states,

> Despite human influences, the fundamental processes that underpin biological change remain qualitatively unaltered across the world's surface. Changes to the abundances and distributions of genes, populations and species are still achieved by the birth, death and movement of individuals, and their interactions determine community composition and ecosystem processes. They are simply doing so in the context of human modification of the physical and biotic environment. (Thomas 2020:2)

Peter Kareiva, the chief scientist for The Nature Conservancy, believes ecologists and conservationists have grossly overstated the fragility of nature, underplaying its resilience. He states, “everything, from the expansion of agriculture to changing waterways, has been painted as a threat to the delicate inner workings of the planetary ecosystem” (Kareiva 2012:3). In his view, the data simply does not support the idea of nature being so fragile. For example, it is now known by ecologists that the disappearance of one species does not necessarily lead to the extinction of any others, much less all others in the same system. And in many circumstances, the extirpation or demise of formerly abundant species will have no discernible impact on ecosystem function (Morar 2015). The American chestnut, once a dominant tree in North America numbering 3-4 billion specimens, was decimated in the early 20th century by a chestnut blight inadvertently introduced from East Asia, yet the forest ecosystem is surprisingly unaffected. In terms of catastrophic events, the 1986 Chernobyl accident is one of the worst nuclear disasters in history, resulting in the creation of a 4,200 km^2 exclusion zone around the former nuclear facility. A recent survey has revealed that wildlife is thriving, despite the high levels of radiation (Deryabina 2015).

IMAGE 4.1 A wolf in the abandoned village of Orevichi, Belarus inside the Chernobyl Exclusion Zone
Source: Vasily Fedosenko, Reuters (March 2nd, 2016)

The Bikini Atoll nuclear test site in the Marshall Islands was subject to twenty-three thermonuclear experiments between 1946 and 1958. Detailed taxonomic reviews of the coral assemblages were undertaken before the tests and fifty years later. The area today harbours as many species as it did before the explosions (Richards 2008). And of course, evidence from prior mass extinctions demonstrates that even when there are planetary mega-events, such as the Chicxulub asteroid impact 66 million years ago that ended the reign of the dinosaurs, life in time can successfully recover and reach greater levels of abundance and complexity.

With this in mind, where does the notion of nature as fragile and passive emanate from? The Latin word natura was originally derived from the verb "to be born" and was linked to a dynamic and vivid idea (Ducarme 2021). Under the Romans, however, the concept began to transform. The meaning of natura in monotheistic cultures was no longer considered a changing process, but a passive and static set of things in the hands of God. Nature became dead matter to which some separate driver (i.e., humans) must add organisation, intelligence, and design. Biodiversity conservation is still rooted in this same reductionist vision of nature (Sarrazin 2016), whereas such a notion finds no purchase in most other societies, something anthropologists have spent years uncovering (Descola 2013). Latour (2017:Ch2) comments that it is one of the great enigmas of Western history that people still hold a naïve belief in what he terms a "deaminate" nature. Philosopher Val Plumwood believes that nature as a realm of creativity and dynamism has been thoroughly killed off by modernity and, in particular, capitalism. If nature is allowed to possess its own strong sense of agency, its own 'active voice', then it cannot so easily be backgrounded, appropriated, and destroyed for human gain and as such cannot be tolerated. This is upheld by scientific reductionism that, in her view, assumes a mindless, meaningless materialist universe open to endless unrestricted manipulation and appropriation: nature is the "suppressed slave collaborator – a mere resource, or transparent enabler of human projects and ideas" Plumwood (2009:12). Such a view of nature is, of course, untenable, particularly in the Anthropocene, where the very unruliness of it is the thing humans now fear the most (Hamilton 2017). It is also unrepresentative of the history of life, something that over billions of years has not only repeatedly surged despite the successive shocks thrown at it but has had a controlling influence on the actual habitability of the planet to ensure its own survival (Lovelock and Margulis 1974). The Earth (and the life upon it) has never been a passive stage – it is constantly metamorphosing, reworking itself to find its own solutions and has an inherent capacity to become different to what it is (Clark and Szerszynski 2020).

So, accepting that nature is neither passive nor static and following the idea that the back loop is a time of "dislocation and possibility" (Wakefield (2017:2) when "unexpected events happen" (Holling 2004:3) as if "somebody threw the…remaining plants, animals, nutrients, energy flows into a gigantic mixing bowl and stirred" (Homer-Dixon 2006:228) can we reflect upon human impacts upon planetary biodiversity differently? Is there an upside to the downside of human activities? It appears there might be. Evidence is coming to light that seems to suggest that the human-mediated translocation of species around the planet, the 'novel' ecologies that are emerging from it, and the ensuing evolutionary impacts of these new biological and ecological configurations are potentially setting the scene for a surge in evolutionary activity that in its scale may match or eventually exceed that experienced over Earth history. From the perspective of the adaptive cycle, we can say that in real-time, the planet is demonstrating its capacity to reorganise and rearrange itself, absorbing the changes and problems human activities are creating and responding creatively with new answers and solutions.

4.5 THE HUMAN-MEDIATED TRANSLOCATION OF SPECIES AROUND THE PLANET – THE 'NEW PANGEA'

As discussed in chapter 1, there is a clear trend over the past five hundred years towards higher extinction rates and there is no doubt that human activities are causing a reduction in both global species and animal population numbers, particularly amongst terrestrial vertebrates and insects. In light of this, it is often assumed that the pattern of extinction is the same across all spatial scales, but an increasingly large literature suggests that at sub-global levels, the loss of native species is being offset by the immigration and establishment of species from outside of their normal ranges into new areas (Vellend 2017; Dornelas 2014). These are often termed non-native,[7] exotic, or pejoratively 'invasive' species. The net impact of these immigrations is that locally and regionally species richness[8] is on average either increasing or staying about the same (Cardinale 2018; Srivastava 2015). Surprising though it may seem, almost all countries, states, and islands are now more biologically diverse than they have ever been (Thomas 2013).

Species immigration involves the arrival of species into an area or habitat where they were historically not present. This can occur naturally when species increase the extent of their native range via long-term dispersal. More common, though, is when species are transported by humans. For certain commentators, one of the defining features of the Anthropocene is the human-mediated translocation of species into areas outside their natural boundaries (Blackburn 2019). Maslin and Lewis (2015) believe the Columbian Exchange[9] of plants and animals, commencing in the late 15th century, which brought together native plants, animals, and diseases from the 'New World' of the Americas, and the 'Old World', consisting of Eurasia and Africa, is a prime candidate for the actual

7 Non-native species are animals, plants, or microbes that have been introduced deliberately or accidentally by human activity to an area in which they do not naturally occur (Pyšek 2008).

8 Local richness is measured on a spatial scale small enough that all the species could encounter each other within ecological time, and so possibly interact. This is the scale that community ecologists usually consider. Examples of local richness are the number of fish species in a lake, the number of grass species in a meadow and the number of gut parasites in a host. Regional richness, or the richness of the species pool, is measured on a larger spatial scale. The regional species pool contains all the species which could eventually colonise a location if competitive exclusion was unimportant (Srivastava 1999:2).

9 See Crosby, Alfred W. 1972. *The Columbian Exchange: Biological and Cultural Consequences of 1492*. Greenwood Press.

commencement of the Anthropocene. It resulted, they state, in "a swift, ongoing, radical reorganisation of life on Earth without geological precedent" (Maslin and Lewis 2015:174). Though the movement of species between locations is a naturally occurring phenomenon, humans have increased the rate dramatically, particularly over the past 500 years or so. A striking example of this can be seen in present-day oceanic trade. It has been estimated that in any given twenty-four-hour period, ten thousand different species are being moved around the world just in ballast water. Thus, a single super-tanker can undo millions of years of geographic separation (Kolbert 2014).

Not only are humans transporting species around the world, but climate change is also significantly altering environmental niches. This is causing species (plants and animals) to shift their habitat range poleward and to higher elevations, as they track their ecological niche to stay alive (Cahill 2012). Climate change is not the only driver of habitat shifts. Other human activities, such as landscape transformation and urban or infrastructure development, are also drivers. However, climate change is dramatically accelerating the rate and requirement for such shifts. Meta-analysis has revealed that, on average, animals are moving 17km per decade towards the poles (Willis 2011). The ubiquity of such movement is such that two-thirds of animals are now living in new places where they could not have survived as recently as fifty years ago (Thomas 2018). With the atmospheric concentration of CO_2 already higher than at any point for four million years (Lenton 2019) and climate change accelerating, an inexorable march of the world's wildlife is underway.

The net impact of the translocation of species by humans and the parallel movement of species to track climate change has been the rapid homogenisation of the Earth's biota which is unique in the history of the planet (Williams 2015). As such, it is recognised as one of the most significant anthropogenic changes in the global biosphere and has even been proposed as a singular ground for the designation of a new epoch, the 'homogocene' (Ellis 2011). Read against life history, this has set in motion a reversal of the direction of biogeographically distinct fauna and flora that has been proceeding since the breakup of the Pangean paleocontinent about 175 Mya. Approximately 300 Mya, the Earth's land surface came together and formed the supercontinent of 'Pangea' (Ancient Greek, meaning 'all land'). Almost all the planet's biota lived on a single giant landmass at the same time. Projecting forward, it is anticipated that the existing continents will again reunite in 50-200 Myr (Mitchell 2012), once more forming a great new supercontinent, named in advance as 'Amasia'. The reconnection of the planet's biota millions of years from now would probably have been the fate of life of Earth anyway. However, human actions have now massively accelerated this. As such, Thomas (2018) believes 'New Pangea' is an apt metaphor for the biological connections of the modern world. He suggests that if the global movement of species continues as is, the geography of the world's animals and plants will have been completely rearranged in less than two thousand years. We are, he states, "in the middle of the biggest biological pile up in world history, an indelible signature of the Anthropocene" (Thomas 2018:Ch5).

The arrival of non-native species into a new area does not automatically result in an increase in the existing diversity. Non-natives can also decrease diversity by facilitating or causing the disappearance of local species and there is also no guarantee they will endure in the longer term. The key metric for biologists is often whether, on average, more or less than one native species is extirpated per non-native that is established. In most cases, there is clear evidence that species diversity increases following the arrival of non-native species (Sax 2003). In fact, extinctions caused by the arrival of non-natives are quite rare and their impacts on other species following their arrival often appear to be negligible (Blackburn 2019). Thomas (2018) cites the case of Britain where 1875 non-native species of plants and animals have established wild populations over the past two thousand years yet there have been no known local species that have died out as a consequence (though there are plenty that have died out for other reasons). There are, however, examples where the arrival of non-natives has been disastrous. In Hawaii, 90% of native snail species on Hawaii are now extinct due to the impact of non-native species (Kolbert 2014). And of the 902 species the IUCN Red List records as globally extinct since 1500, non-native species are in some way implicated in the disappearance of 30% of them (IUCN 2019). However, almost all of these have come on small islands and there is little evidence of non-natives causing continent-wide extinctions (Blackburn 2019).

4.6 NOVEL ECOSYSTEMS

Not only have humans driven the spread of species into regions of the world they would probably never have reached under normal conditions, breaching biogeographical boundaries, but the arrival of such species has helped create a preponderance of what are commonly referred to as 'novel' ecosystems. Though there is no broadly operational definition, the concept of the 'novel' ecosystem is used by ecologists who wish to describe ecosystems with biotic and/or abiotic characteristics in some way altered by humans (Miller 2016). Most often, it is used to describe ecosystems that have species compositions and abundances that have not occurred previously within a given biome.[10] Their key characteristics are: 1) novelty: new species combinations, with the potential for changes in ecosystem functioning; 2) human agency: ecosystems that are the result of deliberate or inadvertent human action, but do not depend on continued human intervention for their survival (Hobbs 2006). It has been suggested that most ecosystems are now sufficiently altered by humans to be considered novel and some are entirely new (Bull 2016). Such is their ubiquity, Pearce (2015) describes them as the 'new world order'.

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10 A major ecological community or complex of communities that extends over a large geographical area characterized by a dominant type of vegetation. Examples include tundra, tropical rainforest, taiga, chaparral, grassland, and desert (Hine 2019).

Change is an entirely normal characteristic of ecosystems in response to disturbance or environmental variations, and species distributions naturally vary over time, often considerably. In that regard, all ecosystems can in some way be considered novel when placed in a particular temporal context (Hobbs 2009). However, the current rapid pace of biospheric change, with approximately 75% of land and 66% of the ocean surface significantly impacted by human activity (Ellis 2008), in conjunction with the effective formation of a 'New Pangea' via anthropogenically driven species movement, sets the current era apart from previous times in terms of the increasing rate of appearance of novel environments, combinations of species, and altered ecosystem function.

Novel ecosystems are most often considered in relation to non-native species or climate change. But they can also occur for other reasons connected to human activities. These include 1) Human impacts causing the reduction or extirpation of some/all the original animal, plant, and microbial populations in an area; 2) Predominating urban, cultivated or degraded landscapes around target ecosystems creating barriers for animals, plants and microbial species to disperse; 3) Human impacts resulting in either major changes in the abiotic environment or a decrease in the original species pool, both of which can prevent the re-establishment of pre-existing species assemblages (Hobbs 2006).

The term 'novel' ecosystem is often associated with the idea that an ecosystem is degraded. But whilst many degraded ecosystems are novel, not all novel systems are degraded (Evers 2018). It is not an a priori truth that the arrival of non-native species into an area will degrade nor even significantly alter ecosystem function. They can cause a range of negative, neutral, and even positive impacts, but clear classification into any of these categories is often difficult, complicated by the requirement for the full spectrum of impacts to be observed within appropriate spatial and temporal contexts. Nonetheless, for most ecosystems, the presence of non-native species will produce only subtle changes to nutrient and energy flows and will not have major effects on ecosystem structure and function (Shackelford 2013). For the most part, the remixed set of species will show the exact same characteristics of a normal ecosystem, including ecological interaction, evolution in relation to the new physical environment, and co-evolution in relation to one another (Thomas 2020).

The precise meaning of what constitutes a novel ecosystem is much debated,[11] including whether novelty is always as a consequence of human actions (Evers 2018). However, there is also a lack of clarity as to what constitutes a 'natural' ecosystem. Whilst most anthropogenic changes to the terrestrial biosphere have occurred over the past seventy-five

11 For an overview of what is an often-turbulent area of debate and discussion, see Miller, James R., and Brandon T. Bestelmeyer. 2016. "What's Wrong with Novel Ecosystems, Really?" *Restoration Ecology* 24 (5): 577–82.

years or so, during the period termed the 'Great Acceleration' (Steffen 2015), human transformation of the planet has been occurring for a long time. The extensive impacts of humans over the past 10,000 years or so are such that Smith and Zeder (2013) have even proposed that the Anthropocene start date should be coaeval with the beginning of the Holocene, 11,700 years ago. A fifth of the Earth's land surface was substantially modified as early as 5,000 years ago (Ellis 2013). By 3,000 years ago, the Earth's terrestrial ecology was already largely transformed by hunter-gatherers, farmers, and pastoralists, with many regions of the planet engaged in significant levels of agriculture or pastoralism (Stephens 2020). By 2,000 years ago, huge areas of Europe and Asia had been deforested. For example, Britain, at that time a remote outpost of the Roman Empire, was already largely deforested and by 1086 less than 15% of natural forest cover existed (Ruddiman 2003). Regardless of whether these early landscape transformations affected global climate or not, as is debated, they are illustrative of the fact that the terrestrial biosphere has a long history of modification and transformation by humans. The extent to which any ecosystem can be considered non-anthropogenic is therefore unclear. By the same token, the precept of what constitutes a native species is also mired in subjectivity. How long does a species need to be present in an area for it to be considered native? The brown hare was introduced into Britain by the Romans 2000 years ago and has been added to the list of British protected species, now accepted and treated as a native. The sycamore tree was added to the British flora about 500 years ago, and many conservationists continue to frown upon it (though it is rarely removed). Based on these two examples, it therefore seems to take from somewhere between 500-2000 years for a species to move from the realm of non-native into the realm of native with no clear rules to justify or explain the inclusion in one camp or the other. Townsend (2005) suggests that by playing around with the temporal and spatial criteria, almost anything can be native or non-native.

4.7 SPECIATION AND THE SIXTH GENESIS OF BIODIVERSITY

Humans, through their activities over the past 10,000 years, have created a cornucopia of new habitats across six continents, impacting the majority of the Earth's land surface and oceans. They have also, intentionally and unintentionally, driven the movement of species around the planet within a rapid timeframe. This has effectively reunified the Earth's terrestrial biology within one giant supercontinent, the 'New Pangea', resulting in never-before-encountered species assemblages within novel ecosystems as modern-day plants, animals, and microbes have colonised the human-altered environment.

The current mass movement of species around the planet into new bioclimatic environments has potentially set the scene for a surge of evolutionary activity, and evidence is increasingly coming to light to suggest that humans are changing the evolutionary trajectory of countless species, potentially stimulating them to diversify and speciate en masse. It has been claimed by Thomas (2018:Ch9) that the current rate at which new species are forming on Earth via the process of speciation is starting to look like, "it is the highest ever, or at least the highest since plants and animals first colonised the land, 450 million years ago"[12].

When species are brought together into novel arrangements, strong evolutionary and co-evolutionary selective pressures can result, particularly if the species in a new community have had little-to-no prior contact (Otto 2018). This can lead to bursts of evolution and hybridisation (the interbreeding of genetically distinct species) amongst hosts and newcomers as they learn to co-exist. Speciation occurs when a lineage splits into multiple reproductively isolated, genetically distinct sub-populations (cladogenesis), but vagueness in clearly identifying species delimitation means there is a grey area between sub-populations that have developed slightly different traits and those that are divergent lineages. It is therefore problematic to define exactly when a speciation event has occurred, i.e., when one or more species can be considered to have emerged from those existing. This, in turn, makes it complicated to calculate speciation rates (Bull 2016). The literature on speciation as a regular component of the evolutionary process is vast, but the focus here is not on speciation more broadly, but rather on the increasing awareness that human activities could significantly influence speciation on a global scale. There are several reasons why speciation events are more likely in the current regime of anthropogenic change. These include that 1)

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12 Can we predict what the future course of evolution might be? It is sometimes tempting to make predictions about future species, but it is also non-scientific. As Ward (2001:79) states, "trying to predict the shapes, colours, and appearances of new species would be fantasy, not science". Yet it is possible to make other predictions based on what we know already through analysing the fossil record and what it tells us about evolution over geological time.

The first thing we can be certain of is that following any future mass extinction, there will be empty ecological niches, and these will be filled by newly evolved species. But which species will fill which ones? Here, speculation is necessary. Gould (1986, 1994) has argued that chance will be the primary arbiter in deciding which species will replace a newly extinct taxon. For example, perhaps the extinction of buffalos and elephants will trigger the evolution of some species of antelope toward gigantism to fill the gap, or maybe the replacement will come from domestic cattle – which it will be, is mostly a matter of chance. Yet other evolutionists are not so sure Gould is correct in this view. Palaeontologist Michael McKinney (1998) has argued that the best chances of filling the vacant niches belong to what he calls 'supertaxa', species belonging to groups composed of many species. Examples include rodents, snakes, and passerine birds – which are all extremely species-rich. McKinney pointed out that, since these groups are composed of generalists rather than specialists, their members are abundant and that the same traits promoting numerical dominance also led to an ability to diversify rapidly over long periods of time. Another characteristic of this group is their small body size.

Second, predicting the makeup of any future biota requires knowledge of what the upcoming range of habitats on Earth will be. While humanity as the dominant species has changed things such as gene flow between once-isolated populations and the commonness of 'alien' invasions, maybe the biggest change has been in habitats. Humans, over recent millennia, have increasingly transformed the Earth's terrestrial surface by producing physical habitats never experienced before (Steffen 2007, Ellis 2011). Through the emergence of megacities, the changeover from old growth to managed agricultural forests, the rapid spread of agricultural landscapes, the fragmentation of native landscapes by roads, changes in the ecology of the oceans because of the reduction of large fish, mangroves, coral reefs, and seagrass beds, and the chemical makeover of land and water habitats with pesticides and other chemical pollutants, humans will undoubtedly have a marked effect on future evolution (Ward 2015). Natural selection will produce brand-new varieties of life in response to a novel set of environmental conditions never previously encountered on the planet.

Speciation events should become more likely when previously isolated species are brought together and given the opportunity to hybridise; 2) Speciation events might be promoted by events such as habitat change that cause previously connected populations to become isolated, thereby pursuing separate evolutionary trajectories; 3) The introduction of 'founder' populations of non-native species into new areas, and the subsequent genetic changes they experience in their naturalised range, could lead to the formation of new species.

Little is known about the extent to which humans have altered the rate of speciation. Most new species will not yet have been detected because they have only recently arisen, remain cryptic, or are highly localised. It is also difficult to demonstrate that a speciation event is human-mediated as it requires drawing a direct causal link between anthropogenic impacts on a population, the emergence of new traits in that population, and eventually genetic divergence (Otto 2018). Nevertheless, Thomas (2013) estimates that Anthropocene plant speciation rates could already be 2-4 times greater than the normal background rate and may be higher than at any point in Earth history. He cites the example of UK plants that are speciating at a rate of 5.2-8.4 S/MSY (species per million species years), exceeding the extinction rate of UK plants, which has been zero since 1700. He also believes that on a global scale, increased speciation is likely occurring with animals, though not as rapidly as plants.

There are good reasons to expect more rapid speciation in the Anthropocene, particularly in species evolving into new niches and responding rapidly to natural selection. However, habitat degradation and environmental homogenisation also have the potential to cause the collapse of what otherwise would have remained or become 'good' species. The net impact of humans on speciation rates globally, even whether it is negative or positive, remains unclear. But much ecological theory suggests that through the removal of isolating barriers and the concomitant mixing of species into new assemblages, species diversity is likely to increase in the longer term (Sax 2003).

Considerable attention is paid to anthropogenically driven species extinction within both the academic and public realms, but not speciation. This is despite the fact that since Darwin's time, it has been known that speciation is a natural and continuous process, tightly bound up with extinction as part of the evolutionary process of natural selection. Furthermore, as discussed in chapter 1, prior mass extinctions have always been followed by rapid bursts of speciation that have seen species numbers eventually *surpass* pre-extinction amounts (Raup and Sepkoski 1982). It is surely reasonable to expect, therefore, that propositions around the sixth extinction should as a minimum include consideration of the potential for rapid speciation as the flip side of the detractive human impacts upon the planet and that based on the fossil record, an evolutionary genesis of new species is always part of any mass extinction event. However, it is rare to find any discussions on the sixth mass extinction that balance both sides of the biological equation, emphasising the loss but not ignoring the gains. For this reason, Briggs (2017) criticises the dominant sixth extinction discourse. He states, "To date, almost all biodiversity loss (extinction) estimates have been made without considering that biodiversity gains (speciation) may have occurred over the same time period. This is the equivalent of calculating one's financial status by looking only at expenditures without taking income into consideration" (Briggs 2017:244). Whilst present-day extinction rates are thought to be significantly elevated above background rates, present-day speciation rates are also thought to be higher (particularly in plants), and it is surprising that they are consistently ignored when talking about extinction. If we want a more nuanced understanding of biodiversity change, we should also have sight of the gains, not simply the losses.

That said, and as described, knowledge gaps determine that it is currently unknown what the net anthropogenic contribution to global species diversity is. But if the likes of Thomas (2013; 2018), Pearce (2015), and Briggs (2016; 2017) amongst others are to be believed, the Earth is currently experiencing or may be poised for a massive acceleration of new species attributable to humans. This idea is supported by Williams (2015) who believes current anthropogenic modifications to the planet are on par with the changes leading up to the Cambrian explosion of animals, 541 Mya. Thomas (2018) believes that humans have created a global archipelago, a species generator, which millions of years from now will eventually give rise to considerably more species on Earth than existed before *Homo sapiens* emerged. He speculates that the long-term evolution of humans may be to increase the number of global species and that amid a new human-created sixth mass extinction, "we should also consider whether we are also on the brink of a sixth major genesis of new life"[13] (Thomas 2018:Ch9). His idea may in the end be unpalatable for the broader ecological community, in their preoccupation with species losses, but prior mass extinctions have always resulted in subsequent surges in species numbers, so based on Earth history there is empirical evidence suggesting he is likely to be correct. What makes the present different though (and likely gives it even greater evolutionary potential) is that prior mass extinctions, whether during or in their aftermath, have never brought species together across the planet in the way that humans are doing in the present and new species are also rapidly coming into existence at elevated rates during the same time as the extinctions, rather than their origins being delayed by millions of years as is normally the case. These aspects alone mark the present extinction episode as unlike anything experienced before over the Phanerozoic eon.

As stated at the beginning of this chapter, the dominant narrative within the scientific discourse about contemporary species extinctions and the broader environmental discourse concerning anthropogenic impacts upon the planet is fundamentally one of loss. However, as we have seen, humans are also instrumental in biological gains. Through human-mediated movement around the globe, many species have now colonised new areas because the human-altered environment is more suitable for them. As such, and despite elevated rates

13 The other five being the recoveries from prior mass extinctions.

of global species extinctions, almost all countries, states, and islands are more biologically diverse than they have ever been. Though comprehensive data is currently lacking, evidence from plants seems to suggest that humans are also likely driving increased rates of speciation as novel assemblages of native and non-native species mix within new environments. The stage has also been set for a massive increase of biological diversity in the future, with the 'New Pangea' paving the way for an evolutionary explosion over the next few million years. With all this in mind, it seems reasonable to ask whether the oft-made projection of imminent planetary collapse is really as bad as the message would suggest. In certain respects, it could be said that nature is responding well in the Anthropocene and many species seem to be benefitting from human presence, occupying and exploiting new ecological niches created by humans via their transformative activities. This information, along with the future evolutionary potential, represents an interesting challenge to our perception of the human impacts upon biodiversity.

Read against Wakefield's experimental proposition of the 'Anthropocene back loop' it also provides a concrete example of how it is possible to see the Anthropocene not as a tragic end or world of ruins, but a time where possibility is present, and the future is more open than is typically imagined. We might say that the sixth genesis of biodiversity is the back loop in action. The loss of biodiversity because of human activities is commonly accepted, but humans may also inadvertently be creating the conditions for big gains and might even be causing them already. Whether such a like-for-like trade-off of species is considered acceptable is another matter and will be discussed in the next section, but a key point to make here is that it is unscientific to consider the Anthropocene as simply a time of loss. Evidence from the history of life on Earth, such as the end-Permian mass extinction 251 Mya when 96% of standing diversity fell, suggests that life can ultimately absorb anything the planet throws at it and over geologic timescales rebound anew. As Margulis (1998:151) states, "Life…is resilient. It has fed on disaster and destruction from the beginning. Gaia incorporates the ecological crises of her components, responds brilliantly, and in her new necessity becomes the mother of invention."

4.8 THE WRONG KIND OF NATURE?

Bull (2016) hypothesises whether it would be deemed acceptable in the longer term if humans were to drive speciation as fast as extinction with a net neutral outcome for species diversity. If species numbers in themselves reflected our concerns, then any gains should temper our anxieties about extinction. However, he guesses that the answer would probably be "no": extinctions cannot acceptably be compensated for in this way – species offsetting is not effective compensation for species loss. Equally, we're aware that the human-mediated translocation of species around the planet, resulting in regional and local species diversity staying about the same or perhaps even increasing, is similarly not believed to compensate for extinctions and extirpations and for many conservationists is considered problematic. As Shackelford (2012:56) notes, "Without resource and methodological constraints, many, if not most, conservationists would still probably prefer to rid systems entirely of non-natives regardless of impact".

Notwithstanding ethical considerations around framing losses and gains of species diversity as trades, concerns around both human-driven speciation and species movement around the planet illustrate that for some, an artificially biodiverse world is just as daunting as an artificially impoverished one. For the most part, this stems from the perception that human activities are somehow disturbing the natural order of things and, in doing so, making nature less natural or even perhaps ending it altogether (McKibben 1989). But how can this be the case? Humans have evolved through the same processes as other species, so how can human actions possibly be considered unnatural? Furthermore, to be human is to always be active in the world and to be in it inevitably means to disturb and transform it. For Thomas (2018:Ch10), the whole idea is nonsensical. He states, "the perspective that 'humans are making nature less natural' is equivalent to saying that 'nature is making nature less natural'". He is no doubt aware that humans are commonly thought to be extrinsic to nature, and it is through this that their activities are perceived as detrimental to its 'naturalness'.[14]

But it is not just that nature is becoming denaturalised, whatever that may mean; it is that humanised nature is effectively not considered worthy of being classed as nature at all. It is thought to lack something that prevents it from being regarded as nature 'proper'. This is evidenced by various key biodiversity trends and indicators that often exclude or marginalise non-native species from their analysis. For example, the WWF Living Planet Index that monitors thousands of discrete animal populations worldwide comprises just 1.5% non-native species. Similarly, the IUCN Global Red List does not evaluate the extinction risk of any species deemed to reside outside of their natural range.[15] This despite non-native species representing a large fraction of modern ecosystems and regional species pools, making up 50% or more of plants and animal species in some environments (Schlaepfer 2018). These environments can offer significant conservation value both in terms of biodiversity and the provision of ecosystem services (Kareiva 2012).

To be unhappy about the replacement of nature by a humanised world would seem to necessitate being able to point to some empirical characteristic the natural world possesses that a humanised world does not. This would be expected to extend beyond any claim to its naturalness alone, if naturalness simply means its independence from human influence, on the basis that the concept of the Anthropocene is predicated around the idea that human impacts upon the Earth System are such there is now no nature free from human influence anyway.[16] Any

14 For Philosopher Steven Vogel (2011), the distinction between humans and nature is crucial to the majority of environmental thought. It is dependent upon the dualism that treats humans as exceptional creatures that somehow transcend the natural. He considers this both philosophically and biologically untenable.

15 As noted in section 4.6 the designation of what constitutes a natural range is often entirely subjective, based on the temporal and spatial criteria employed.

16 Perhaps with the exception of microbial communities within geological substrates.

unhappiness about humanised nature would therefore have to be for reasons over and above this, lest the entirety of nature is now deemed lamentable.

Pinning this empirical characteristic down is challenging and may in fact be impossible, centred as it is around what is understood by the term 'nature', which as literary critic Raymond Williams (1983:219) observes is perhaps "the most complex word in the English language". It is an elastic idea that provides an ideological vehicle for almost any position between humans and their environment. Purdy (2015) suggests that 'nature' is maybe one of those concepts, like 'race', that confuses more than it illuminates and does more harm than good. It can invite narcissistic projections of nostalgia towards a pure and timeless environment free of human influence that is implicitly objectivist, ahistorical, and misanthropic. In the Anthropocene, where the only constant is seemingly exponential change, such projections are unhelpful, but they do suggest why humanised landscapes and species compositions are often poorly regarded. If environmental conservation ultimately treats change as negative (Thomas 2018), and the default position is to want to keep ecologies and species pools as they are or how they were once thought to be before much in the way of human influence, then it is hardly surprising that the unruly, unpredictable 'emergent ecologies' (Kirksey 2015) of the Anthropocene should be so feared.

But as Watson (2020) suggests, these ecologies are likely to be the most future-proof and they offer the best hope for species lineages to persist. Humans are creating new ecological niches and species are spreading into them, taking advantage of the favourable conditions they find. There is nothing abnormal in this – it is how biological and evolutionary change works and simply reflects the dynamism and resilience of life. That these species are arriving under human influence, whether by immigration or in situ speciation, adds an unusual dynamic of course, but I suggest that it does not make them any less natural nor worthy of respect. For some, non-native species inhabiting new ranges en masse – the 'New Pangea' – and the potential for human-mediated hyper-speciation can be held up as a prime example of an Earth out of whack due to human actions. For others, they can be thought of as life making a fresh start, the flip side to all the damage and disturbance. These are entirely subjective judgements. Opinions about the worth of certain species over others, where species do and don't belong, the benefits derived from historic versus novel ecosystems, and the importance of diversity across different spatial and temporal scales are ultimately societal issues for which there cannot be universal 'correct' answers.

Notwithstanding any of these important considerations, the non-human world will nevertheless proceed anyway, taking multifarious pathways in response to human disturbance. This is what happens in the back loop and, as Wakefield emphasises, actively inhabiting it empowers us to see the present as something not just as a time of loss, but also one with potential as life bursts forth in new directions. If we want to learn to survive on a 'damaged planet' (Tsing 2017) we may have no choice but to accept new environments, species configurations, and life forms as a consequence of our activities. For many, these might not be accepted as natural, but in terms of the ongoingness of life, they are probably natural enough.

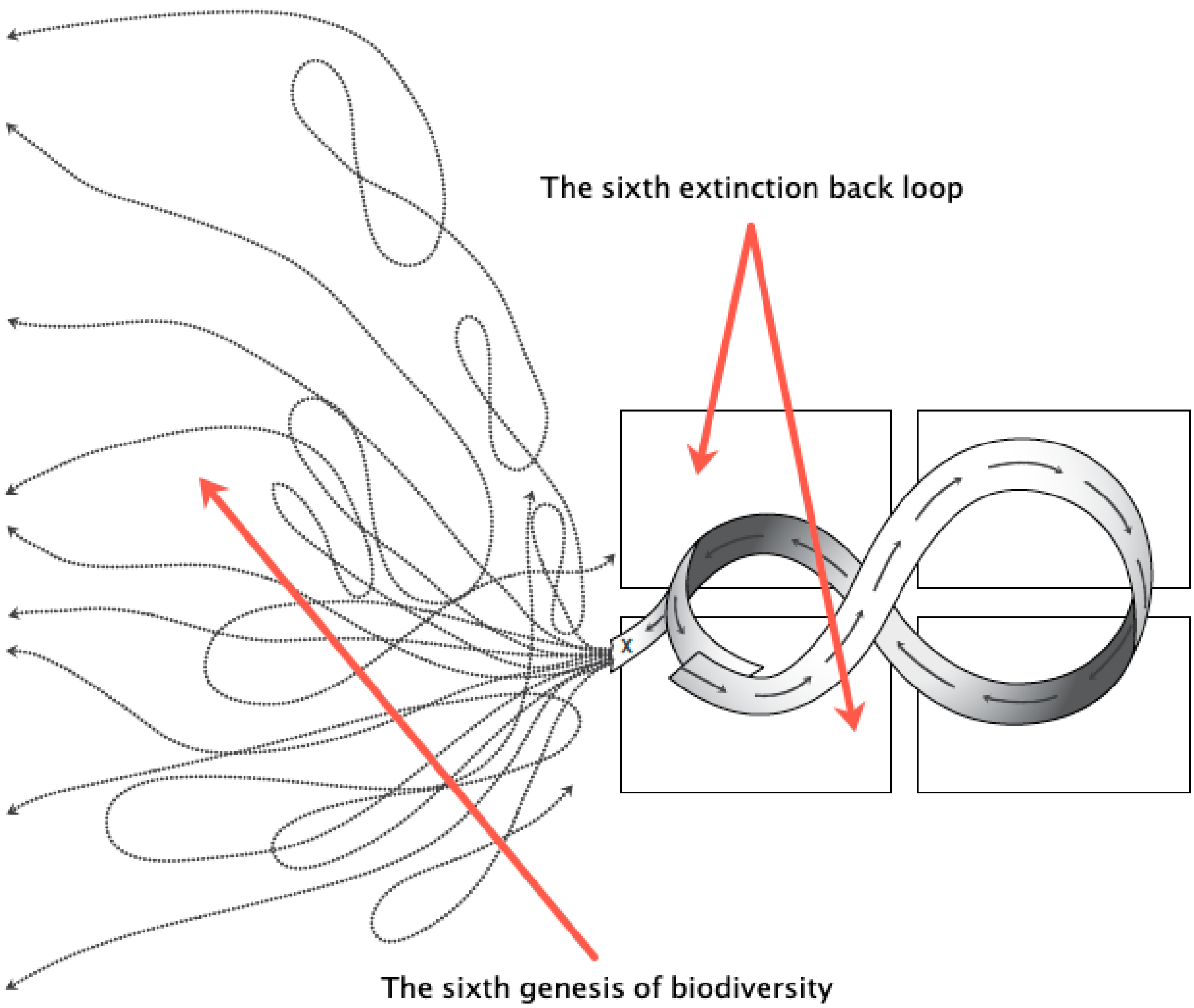


DIAGRAM 4.3 The adaptive cycle modified to reflect the possibilities of the sixth extinction back loop
Source: Adapted from Wakefield (2020)
The dotted lines represent the multitudinous evolutionary possibilities of the sixth genesis of biodiversity. The trajectories are unpredictable and will not always be successful.

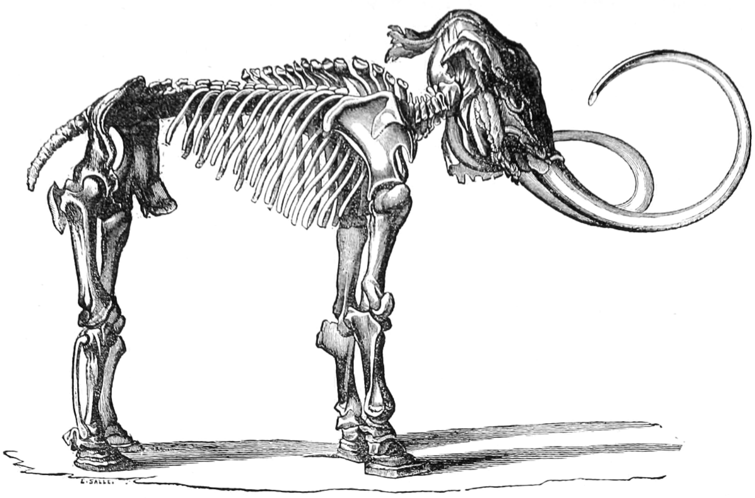
4.9 CONCLUSION

Whereas the opening chapters of this thesis were mostly focused on the loss aspect of extinction and Anthropocene discourses, this concluding chapter has framed things differently. It has attempted to identify potential upsides resulting from human impacts on the global environment that provide an alternative reading to the fatalistic 'end of world' tone within much of the discussions. This commenced by exploring Holling's resilience theory and Wakefield's experimental idea of the 'Anthropocene back loop'. She proposes that rather than simply seeing the Anthropocene as a time of dislocation and crisis, viewed through the lens of the adaptive cycle heuristic we can also identify it as a time of opportunity, where possibility is present, and the future is more open than is popularly imagined.

The back loop logic was then adopted and considered relative to species loss. I asked whether there might be what I termed a 'sixth extinction back loop' – biological consequences of human activities that may offset some of the impacts of the extinction crisis. I suggested that emergent ecological and biological gains emanating from the Anthropocene have mostly been overlooked within the discourses on species extinctions. This, I speculated, might be driven by an outmoded conception of the natural world that perceives nature as a static and fragile object unable to actively respond to human impacts upon it, something that has a long history in Western thought, but which is demonstrably inaccurate not least in the recovery of species from prior mass extinctions.

I noted that whilst global species diversity is in decline, the human-mediated translocation of life forms around the planet over the past 500 years or so, an indelible signature of the Anthropocene (Maslin and Lewis 2015), is such that most countries and islands are now probably more biologically diverse than they have ever been. Furthermore, human activities have effectively formulated a biological supercontinent, the ‘New Pangea’, bringing together species from around the planet en masse into new arrangements. These never-before-encountered configurations are resulting in a preponderance of novel ecologies. Though evidence is currently patchy, they are also likely driving elevated rates of speciation, setting the scene for what has been termed the ‘sixth genesis of biodiversity’ (Thomas 2018) millions of years from now when as a direct consequence of human actions, species number may reach levels unheralded in Earth history. This aligns with empirical evidence from prior mass extinctions, identified by palaeontologists as important creative destructive events, where species richness and complexity over time eventually exceed pre-extinction levels.

Such a view, I noted, presents a challenge to the dominant loss narrative and the often-made projections of imminent planetary collapse. It also leads to a confrontation with the concept of nature and whether the humanised or human-influenced ecologies and biologies of the present/future should be lamented or welcomed. This is because, despite their perceived ‘unnaturalness’, they offer significant conservation value, including perhaps the best chance for many species lineages to persist over time. None of this, of course, is to contest the fact that anthropogenic activities are likely driving extinction at rates way above normal background levels nor to imply that we should not try to avert further global biodiversity loss. It does suggest, though, that if we want to see the future more hopefully, we have little choice but to actively, and for the benefit of all life forms, try to ‘inhabit’ the sixth extinction, seeing it not solely as a time of crisis but also as a time of emergent possibility. This will inevitably involve confronting our preconceptions about the natural world and the human place within it. However, to do otherwise would fail to recognise the inherent dynamism of life on the planet and its capacity to respond to whatever challenges and opportunities it encounters.



MAIN CONCLUSION

5.1 INTRODUCTION

This concluding chapter provides a brief overview of the thesis, beginning with a summary of my primary research questions, key findings, and how and where my research might be beneficial. I engage in a short discussion about two additional aspects of extinction that, whilst not directly discussed so far, hold an overarching presence within much extinction discourse, including my own. I also declare what I consider this thesis's main limitations, some of which were unavoidable, others because of the intellectual choices I have made. Building on this, I make some suggestions for future research, including the possibility of undertaking ethnographic fieldwork and also investigating what, for some, is one of the solutions to the extinction crisis: de-extinction.

5.2 RECAP OF CHAPTERS 1-4

This thesis has been a work of critical analysis, examining what I consider to be some of the key aspects of extinction research. Via four interrelated chapters, I have scrutinised both scientific and cultural aspects of extinction, providing what I hope is a reflexive analysis of this vast subject area.

The main research questions I sought to respond to by chapter were:

1) Are we in the sixth mass extinction?
2) Given the indeterminacy of the scientific data, what explains the considerable interest in the sixth extinction and species loss overall?
3) To what extent are concerns about the environmental crisis, including the sixth extinction proposition, a manifestation of ontological fears about the end of the 'modern world'?
4) If the Anthropocene and the sixth extinction are as much a crisis of thought as a crisis of life, is it possible to rethink or reimagine our collective planetary predicament that does not simply reduce the future to loss?

In the main introduction, section 0.9, I summarised the thesis's main findings. These were extensive and varied, but the main ones are:

- The sixth extinction proposition is a speculative label currently unsupported by empirical science. There is not enough data to affirmatively make such a declaration.
- The sixth extinction is an inappropriate model to discuss the crisis of anthropogenic species loss. This is because, over geological timescales, mass extinctions have been creative destructive events that have always led to increased species richness. Over the past half-billion years, they have been the engine of macroevolution and the ongoing development of complex life.
- Ideas of extinction have changed dramatically over time. In little over two centuries, they have transformed from being wholly denied, accepted, welcomed, to being something many now view with dismay and horror. Though these transformations have mostly been a result of scientific developments, including Darwin's theory of evolution and the discovery of geological mass extinctions in the 1980s, they have also, from the onset, been strongly influenced by other societal factors, including religious beliefs, global events such as the Cold War, and existential concerns about the state of humanity.
- The sixth extinction proposition and the broader ecological concerns about the state of the planet as they manifest within the Anthropocene discourse can simultaneously be interpreted as an expression of ontological concerns about the collapse of the 'modern way of life'. Or, to phrase things differently, the end of the 'modern world'.
- It is rare to find any discussions about the sixth extinction and the biodiversity crisis balancing both sides of the biological equation, emphasising the losses without ignoring the species gains occurring in the present and probably in the future. Regardless of whether humans are causing the sixth extinction, we are likely setting the stage for the 'sixth genesis' of diversity millions of years into the future, something I experimentally term the 'sixth extinction back loop'.

My biggest achievement, and what might be described as my primary 'contribution to knowledge' is, I suggest, the production of a deep, reflexive, and critical review of extinction research where I have carefully and selectively synthesised discourses from an array of disciplines to answer my research questions. I have pursued, connected, and interrogated countless research lines – scientific, philosophical, anthropological, and historical – and placed them in close conversation with one another in a way I believe is original, engaging, informative, and empirically thorough.

As I have consistently emphasised throughout this thesis, there has been relatively little direct anthropological engagement with contemporary species extinction or the possibility of the biological discontinuation of *Homo sapiens*. In the first instance, therefore, this thesis should be a welcome addition to the discourses of environmental anthropology, human geography, and other environmental-social science disciplines. It will be helpful for researchers who may want a more comprehensive understanding of extinction science, including mass extinctions, the cultural and discursive history behind it, and how it maps onto broader societal fears about the future of humanity. Natural scientists may similarly find these latter societal aspects of use.

5.3 DISCUSSION

There are two aspects of extinction I would like to draw out as part of my closing remarks that might be considered an addendum to the discussion thus far. These separate but related elements – time and ethics – further confirm the dizzying array of considerations researchers must wrestle with when addressing the discursive 'hyperobject' of extinction, including efforts to mitigate anthropogenic species loss. Neither of these was addressed extensively in the main chapters, though I suggest they have a spectral presence throughout this thesis and in the majority of extinction discourse. As part of the broader Anthropocene discussion, they are also subject to ongoing attention, particularly within the environmental humanities, by scholars such as Bastian (2012) and Hatley (2012).

Extinction is a profoundly temporal issue. Depending upon the temporal prism through which one views the current human-driven episode of rapid species loss, one can have an entirely different reading of its significance. If one considers it from the viewpoint of the human lifecycle or the temporalities that animals live and die, the problems of extinction appear unassailable: living arrangements are coming undone in front of our eyes, and we are experiencing the 'biological annihilation' of many types of planetary life. Yet, if one takes a longer-term, geological perspective, where species loss, including catastrophic mass extinctions, is recognised as a regular, important aspect of evolutionary processes, it is possible to hold a wholly different view. From this long-term standpoint, the biodiversity crisis can be seen as just another episode of species loss in Earth history and, in the grand scheme of things, probably not a crisis at all. Ninety-nine per cent of the estimated four billion species that have ever lived have gone extinct. Extinction would seem to be the destiny of all species and as far as we know, the cosmic default in the universe. We also know that the long-term trend over geologic time frames, despite the regularity of mass extinctions, is the accumulation of more species on Earth (chapter 1, diagram 1.2). Human activities are now slowing the process, but nothing suggests this will be anything other than temporary (discussed in chapter 4). In other words, whatever humans do in the short-term will, in time, probably subsume itself into the deeper long-term patterns of natural history. As Hamilton (2017) states, one day, the Earth will forget humans.

This alerts us to one of the challenges of extinction research, particularly consideration of the proposed sixth extinction. That is, the need to hold different senses of time in view at once and somehow reconcile and incorporate them both into our thoughts and writing: the 'homo' or human-centric viewpoint which pays attention to the immediate impacts our collective activities have upon the lives of species; and the 'zoe' or life-centric perspective, which keeps an eye on the 'big history' of the past and the deep future ahead.[1] Each of these scales of analysis and thinking tells a very different story and provides unique insights unavailable from the other. They also, on the face of things, seem incompatible.

Planetary processes, including ones that humans have interfered with, operate on various time scales. Some are compatible with human temporalities and concerns; others are vastly larger than what is involved in human calculation. Extinction is a prime instance of the latter. As detailed in chapter 1, for example, recovery from mass extinction events, including the reestablishment of some communities, may take as long as 5-10 Myr, time scales that, based upon the anticipated future lifespan of *Homo sapiens* (discussed in chapter 3), are essentially meaningless to us.

Natural scientists can take sides based on scale. Palaeontologists, for example, might take a prosaic, long-term view, shrugging off the sixth extinction as just another crisis in the history of life, whilst others, such as conservation biologists, may fight for the survival of a single species. Regardless of how one feels about anthropogenic species loss, any proper critical analysis of it demands a confrontation with the history of planetary life over deep time. This is essential to ascertain a relative understanding of contemporary extinction patterns, processes, and intensities compared to past ones. But deep time is so alien to us as part of our daily lives that we can only really comprehend it as a metaphor, which is one reason why conceptualising mass extinctions is challenging for researchers. As Gould (1987:3) wrote, "an abstract, intellectual understanding of deep time comes easily enough – I know how many zeros to place after the 10 when I mean billions. Getting it into the gut is quite another matter".

Miller (2016) has observed that the horizon of scientific studies on climate change is dominated by the short time interval that extends between 2050-2100. He suggests our concerns are limited by what we can imagine or what is comprehensible to the public; namely one human life span. I contend this also is the case with many studies of extinction. For example, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services' recent Global Assessment (IPBES 2019) estimates one million animal and plant species are at imminent risk of extinction 'within decades'. Wilson (1992:Ch3) similarly states, "humanity has initiated the sixth great extinction, rushing to eternity a large fraction of our fellow species in a single [human] generation".

The capacity of anthropology to think over much longer time frames has, historically at least, also been limited. As Irvine (2020) notes, the fundamental periodicity of anthropology

1 For a detailed discussion on this, see Chakrabarty, Dipesh. 2015. "The Human Condition in the Anthropocene." In *The Tanner Lectures in Human Values*. Yale University.

is the human life cycle, something he believes seriously inhibits the capacity of anthropologists to understand the present. He suggests that "the material conditions of human existence can only be understood as the product of processes occurring over deep time. To isolate ourselves from these geological flows is to distort our understanding of society and humanity" (Irvine 2020: Introduction). Danowski (2016) suggests that the rift between the cosmological and anthropological orders, between a cosmological deep time and a human-historical time – something that has been extensively discussed in the Anthropocene discourse (Chakrabarty 2018) – recreates the age-old tensions of the distinction between nature and culture (discussed in chapters 3 and 4), that anthropologists have wrestled with for decades.

As discussed in Chapter 4, one possible way of engaging with this is through resilience theory and appropriating the idea of the 'back loop' – something I experimentally termed the 'sixth extinction back loop'. Such 'deep future thinking' (Skrimshire 2019) provides a viable way out of the paralysing and catastrophic conception of the present - the idea that in the long-term, everything will be ok. However, this arguably risks naturalising and arguably even trivialising species loss, creating indifference to the many deaths occurring now. It also fails to recognise the empathetic engagement humans have with other life forms, the trauma human communities face because of the loss of familiar species, and the broader sense of being at home in a multispecies *oikos* (Jones 2020). As Haraway (2008) notes, other species are full partners in our own 'worlding'. Without them, there is no us.

From an evolutionary perspective, despite human influences, the fundamental processes that underpin biological change remain qualitatively unaltered across the Earth's surface (Thomas 2020). As described in chapter 4, some biologists even speculate that human activities in the Anthropocene, millions of years hence (after we are long gone from the planet), might be to the overall benefit of planetary life and that species richness will reach unprecedented levels.

Species are valuable to humans for a host of reasons. They provide food, medicine, material, fuel, recreation, tourism, and spiritual anchoring points. As part of general biodiversity, they also help provide functioning ecosystems supplying oxygen, clean air and water, pollination of plants, pest control, wastewater treatment, and many other ecosystem services (Maier 2012). Some even suggest they are crucial for the ongoing habitability of the biosphere (Lovelock 1995; Lenton 2020). But as Rolston (1985) notes, on an individual level, many endangered species probably have no resource or spiritual value to humans and, from a utilitarian standpoint, may not matter much, anyway. To concern ourselves with species loss, we must therefore think beyond instrumentalism toward closer ethical engagement. This recognises that, for the most part, it is an ethical and moral choice to concern ourselves with the well-being of other species, most of which have been neither seen nor recorded by science.

For philosopher Thom van Dooren (2014), there is an ethical claim made upon humans to hold open space in the world for other species. We are summoned to do so, he believes, by nothing less than all the living things that have ever populated this planet, as well as those that might yet come, to allow their dense histories – histories far exceeding our own – to diversify and resonate into the future through "endless forms most beautiful and most wonderful" (Darwin 1859:ChXV). Species are the primary expression and repositories of organic nature's order, creativity, and diversity, representing billions of years of evolutionary achievement. They show incredible functional, organisational, and behavioural complexity. Every species, like every human, is unique with its own history and destiny. When a species becomes extinct, a valuable and meaningful story comes to an end.

To live in the world, to live in connectivity, is always to be living in proximity to death as well as to life, to cause death as well as to nurture life (Rose 2011). All creatures, in some way, are touched by the deaths of others and profit from it. However, recognising the inevitability and presence of death as part of our relations with other species does not diminish the injunction to minimise and reflect upon it and try to be as ethical as possible in our interactions.

Ethics is a sub-discipline of philosophy that has historically only been concerned with humans and human affairs (Hargrove 1989). As part of a wave of environmental consciousness taking shape in the 1960s and 1970s, environmental ethics emerged with the primary aim of pushing ethics beyond the human realm. Despite its prominence within conservation, where along with science, it is one of two pillars of the 'conservation cathedral', it remains a tentative intellectual project (Batavia 2017). There is no universally accepted philosophical foundation of environmental ethics, and a diversity of perspectives co-exist.[2] Zylinska (2014) describes ethics as a mode of human locatedness in the world involving the recognition of the processual and unstable nature of such locatedness and of the human that is thus located. It also obligates humans to give an account of the modes of relationality that ensue. In that sense, ethics is not just about being-in but also about being-with. To be ethical, she believes, requires the suspension of humans' epistemological and domineering pretensions, where we account for the incisions we make into the ecologies of life, act upon them, and become "better in the world" (Zylinska 2014:93).

For Rose et al. (2017:Introduction), the problem of extinction is one of the gravest challenges to ethics and action confronting all of us today. The reverberations of our inadequacies are, she believes, "everywhere apparent". But what does it mean to develop an ethical relationship with extinction? How do we move beyond ontological paralysis toward a position of responsibility? Van Dooren suggests that dwelling within it – taking it seriously, not rushing to overcome it – may be some of the most important ethical work one can undertake. He states, "the reality is that there is no avoiding the necessity of the difficult cultural work of reflection

2 This includes anthropocentrism (human beings alone are moral agents), biocentrism (moral standing expanded to nonhuman subjects who have inherent value), and ecocentrism or holism (ecosystems and the biosphere as the ultimate reference of moral value) (Mackey 2014).

and mourning. This work is not opposed to practical action, rather it is the foundation of any sustained and informed response" (Van Dooren 2017:2). For him and collaborators, such as Rose, a primary task is to understand how and why extinctions occur. This entails continually learning from them and thinking them through, rather than jumping to conservation or technological solutions that purport to halt the process by keeping a few individuals alive or trying to bring them back from the dead via initiatives such as de-extinction (discussed further in section 5.5, below). What is needed is the kind of difficult reflection and discussion that forces us – as individuals and cultures – to dwell within our actions and their consequences and, in so doing, perhaps begin to dial back the current rate of extinctions. The underlying ethical command is thus: their deaths should not be in vain.

5.4 LIMITATIONS OF THIS THESIS

Any study on topics as massive as extinction and the Anthropocene will inevitably have limitations. My research is no different - it is not and could never be a definitive critical analysis. Some of these limitations are a consequence of personal interests, leading me to focus on specific research lines at the behest of others. Others are because of individual circumstances, including my status as a part-time, self-funded student, that have restricted the choices available to me. Others still can be explained by information availability, involving an overabundance in certain areas and a shortfall in others. I provide a summary of those I consider the most significant.

Focus on macroscopic life

A notable and unavoidable limitation of this study is its focus on macroscopic life. Almost all the discussions about mass extinctions in the Earth's past and anthropogenic extinctions over the last 50 kyr focus on visible life, despite the fact that microscopic life, by biomass, exceeds that of all plants and animals combined (Quammen 2018). The vast majority of the planet's lifeforms are microbes, and they determine the conditions of existence for the rest of us (Margulis 2000). Without the bacterial biosphere, no other life would ever have evolved, nor would it be alive today. Yet we know very little about it. Microbiologists have no idea about the number of microbial species, though estimates are as high as one trillion (Locey and Lennon 2016). The extinction status of archaea and bacteria – two of the three primary domains of life (chapter 1, diagram 1.4) – is a mystery and remains absent from any Red Lists. So far, microbes have been mostly ignored by conservation biologists (McFall-Ngai 2017) though some researchers have suggested microbial evolution is keeping pace with the environmental changes wrought by humanity (Gillings 2014). We also have no fossil record of our bacterial ancestors, which is comprised almost entirely of plants and animals. From a microbial viewpoint, some authors have speculated the 'big five' mass extinctions may not have been mass extinctions at all (Nee 2004). Overall, the status and history of biodiversity among microorganisms are too poorly known to make any comparison and generalisations about the current pulse of extinction relative to events in the deep past. This suggests that perceptions of our collective impact on the planet as equivalent to a mass extinction, focused as it is on macroscopic life, reflect the evolutionary and spatial prism we choose to view life. One can only speculate how our judgment of the environmental crisis might change if there was adequate data about microbial life.

Minimal focus on the marine realm

Most of the evidence and discussion about anthropogenic species extinctions emanates from the terrestrial realm, with little data available from the marine realm. As discussed in chapter 1, this contrasts with the fossil record, which primarily comprises marine invertebrate species such as trilobites and ammonites (Jablonski 1994). Contemporaneously, very little is known about the status of life in the Earth's oceans. It has been estimated there are currently 2.2 million marine species (Mora 2011) but only about 104k have been formally described, with less than 7k assessed by the IUCN for threat status. Just 20 global marine extinctions have been recorded (4 mammals; 8 birds; 4 molluscs; 3 fishes; 1 alga) though many others could be functionally extinct because of economic exploitation (IPBES 2019). Unlike the terrestrial realm, marine defaunation started only a few hundred years ago and until recently, has been less severe than on land (Dirzo 2014). However, McCauley (2015) thinks that today's low rate may be the prelude to a large extinction pulse, like that observed in the terrestrial environment during the industrial revolution. Webb (2015) thinks the risk for the best-known marine groups is now at least on par with the non-marine environment, and the much lower rate of recorded extinctions and lower extinction risk can be explained by the number of species assessed. The rich fossil record for marine animals provides an opportunity to compare current trajectories of change with deep time patterns, though this has yet to be undertaken (Payne 2016). Overall, little is known about species extinctions in the world's oceans and whilst there is currently little I can do to address the issue, it is an obvious limitation of this study that needs to be flagged.

Minimal investigation of the drivers of anthropogenic extinctions

As mentioned in my introductory chapter, this thesis has not investigated the causal drivers of species extinctions nor delved too deeply into exploring the responsible human agent. Unlike climate change – the main focal point of much Anthropocene discourse – anthropogenic extinctions cannot so easily be attributed to capitalist modernity and its repercussions (though these are certainly part of the story). As described in chapter 1, the first known extinctions attributable to humans are thought to have occurred between 10-50 kya during the late Quaternary period, when human geographic expansion and population growth worldwide contributed to two-thirds of all mammalian megafauna becoming extinct everywhere except Africa (Martin 2007). This event was an extinction spike exceeding all but one episode over the past 55 Myr, and the loss of phylogenetic diversity has no analogue within the fossil record (Davis 2018). Paleoanthropologist Todd Braje (2013) argues that these extinctions, and those that followed over the Holocene, can arguably be seen as part of a single complex continuum driven by anthropogenic factors that continue until today. This is complex, controversial, and uncertain research territory, riven by countless debates stretching back decades, warranting a dedicated thesis of its own. It would, I suspect, run into many of the empirical issues associated with the evaluation of prior mass extinctions and present-day anthropogenic extinctions, as well as a host of sensitive ontological and political arguments. For this and other reasons, I chose not to focus on it here though I acknowledge it is a significant aspect of extinction research that could impact some of my ideas.

Broad-ranging nature of my research

This is a broad-ranging thesis analysing material across many disciplines, particularly the natural sciences. Recognising the enduring power of scientists to affect and influence the thoughts and actions of other non-scientific disciplines, such as anthropology, I try to get my hands dirty in the places those scientists operate. Castree (2014:44) describes this as being an "engaged analyst". The engaged analyst, he states, is someone "serious about both the science and their own skills" who "seeks…epistemological forms of engagement that might alter important conversations occurring outside the humanities". Certain humanists interested in science have become engaged analysts (e.g., bioethicists who work at the science-policy-society interface of biotechnology). But not too many exist yet who engage the claims emanating from geoscience and extinction research. As stated in my main introduction, I contend that one of the primary outputs of this work is that I break new ground within anthropology through my reflexive engagement with a wide gamut of extinction-focused scientific disciplines. However, I also acknowledge that my knowledge of extinction science remains cursory - I have no formal training and am self-taught. Without peer review of my research from experts in the field, particularly in chapters 1 and 4, it is possible I have erred in some of my analyses and conclusions. This leads to a broader point that the expansive nature of what I have produced, where I step into the natural sciences and other disciplines, may simultaneously be this project's greatest strength and weakness. In other words, by being an 'engaged analyst', I may have spread myself too thin.

Absence of an ethnographic component

The absence of an ethnographic component by the conventions or expectations of academic anthropology is potentially a limitation of this research because ethnography and anthropological analysis are often bound up together. However, as explained in the main introduction, section 0.8, I believe there are justifiable practical and epistemological reasons for my approach that may have resulted in arguably my most useful output – a 'thick description' (Geertz 1973) of extinction science that might be useful to non-scientists.

However, I recognise that within the academy, some might consider my work incomplete or insufficient. Within the next section, I describe a possible avenue such research might take, perhaps during post-doctoral studies.

5.5 SUGGESTIONS FOR FUTURE RESEARCH

With a topic as vast as extinction, there are inevitably innumerable possibilities for future research. This could involve analysing individual chapter contents in greater detail, such as a deeper investigation of the conceptual emergence of extinction, particularly the influence of global events over the late-19th and 20th centuries, such as the Cold War, and how they have helped shape the ideas we now have about extinction. It could also include taking the analysis in other directions, including the ethnographic realm. To conclude, I will describe two options for further research, though there are countless others I could doubtless identify.

Ethnographic investigation

This thesis has been a work of theoretical critique. But it has the potential to become a work of action that I hope may help develop better questions and approaches to extinction. This might involve undertaking ethnographic, field-based research that could include working with conservationists, extinction biologists, and palaeontologists, amongst others, to further investigate some of the epistemological aspects of extinction. It could also involve the study of species that are on a pathway towards extinction, working with and around them and the human groups directly impacted by such threats. As Heatherington (2012) notes, the scientific focus on species as genetic entities and resources often fails to recognise the importance of the locally embedded and culturally meaningful patterns of human-animal relations impacted by the losses.

A practical problem in the study of extinction relates to geographical scale and its operational definition – global disappearance. The scientific focus of extinction is usually on the final disappearance of a particular species from the Earth, something Jørgensen (2017) terms 'the endling'. Science gives a species a name, acknowledges its worth, and asks humans to empathise with the imminent end of its entire genetic line. It recognises the permanence of extinction on an individual species level. However, as Garlick (2020) points out, there is no singular extinction for a species. Only a multiplicity of sited extinctions spread over time and space, which eventually amounts to its global disappearance. It is, therefore, never a generic, 'global' event. It is always a geographically specific, multi-contextual phenomenon that is experienced, resisted, measured, enunciated, and performed in a variety of ways that can be attended to by researchers (Wolfe 2017). Tsing (2005, 2012, 2015, 2019) has written repeatedly about the challenges of making the globe a frame of reference for anthropological study. As she states, none of us lives in a global system; we live in places. Extinction and the Anthropocene (by the definitions of science) may be planetary in scope, but our grip on collaborative survival is always situated, patchy, and ultimately local – the familiar territory of anthropologists, therefore.

Humans and other animals on an everyday level may not reside within a global system, as Tsing points out. But neither the species nor the individual ever stands alone and outside a system. Ecologically, all living things are bound-up in the webs of exchanges that make life possible. As Van Dooren (2014:40) observes, “Everything is connected to something, that is connected to *something* else”. It is these connections that are becoming undone in the Anthropocene, often in ways that on a day-to-day basis may not be easy to discern. Van Dooren (2014) describes this as the ‘dull edge’ of extinction: a slow unravelling of entangled ways of life that begin long before the death of the last individual.

These entanglements are increasingly becoming the focus of humanities researchers, most recently in the emergent area termed ‘extinction studies’ (Rose et al. 2017). Extinction studies have a particular focus on responding to processes of collective death, where not just individual organisms but entire ways and forms of life are at stake. Their work may not meet the definition of extinction recognised by biologists, as the focus of their work is not always on critically endangered species per se (see, for example, Rose 2011). But certain facets of extinction are being studied – disappearing of ways of life or lived relations, for example – if not the final biological extinction of species globally. ‘Extinction studies’ research converses with a growing body of work in the humanities in the broad area of ‘multispecies studies’. This work is taking place under a range of labels, including ‘multispecies ethnography’ (Kirksey and Helmreich 2010), ‘anthropology of life’ (Kohn 2013), ‘anthropology beyond humanity’ (Ingold 2013), and ‘more-than-human geographies” (Lorimer and Driessen 2014; Whatmore 2002). Scholars in multispecies studies have aimed to provide ‘thick’ accounts of the distinctive experiential worlds of other species that “unsettle the hegemony of scientific accounts of nature” (Van Dooren 2016:9). They aim to critically refigure the human, moving beyond exceptionalism, whilst problematising and working across the nature/culture nature/human dualisms.

Fieldwork is a central component of both ‘extinction studies’ and ‘multispecies studies’ work, and it seems a logical development of the research undertaken in this thesis. Armed with a solid knowledge of extinction science, the history that has shaped it, and awareness of how species extinctions jut into the ordinary world of humans, I am well-positioned for further research involving a direct immersion into the lives of humans and non-humans alike. This, I hope, may further the overall understanding of this most pressing yet simultaneously natural phenomenon. A potential geographical study area to pick this up is Western Amazonia. As stated in the main introductory chapter, my original PhD proposal - abandoned for financial and practical reasons - involved research in this geographical area. The tropical forests of Amazonia are probably the frontier of species extinctions globally (Nobre et al. 2021). Yet research on how biological extinction registers within Amazonian cultures, indigenous and otherwise, is, I believe, little-explored within Amazonianist literature. As Viveiros de Castro (2013) has vividly described, the ‘perspectival’ view of life and the wholly different notion of species within many Amazonian societies mark it as a fascinating area to explore other ideas of extinction.

De-extinction

My research has focused on the issue of extinction and species disappearance. But an emerging and related topic that would be an obvious expansion of my work is the subject of 'de-extinction' – the forced reappearance of species. Since Darwin published *On the Origins of Species* in 1859, it has been the norm to view extinction as something permanent and irreversible, be it through species evolving into new forms or because all the individuals die off before they can reproduce. "Neither species nor groups of species reappear when the chain of ordinary generation has been broken", as Darwin (1859:ChXI) emphasised. This basic idea has been one of the main pillars of this thesis and is the central assumption of most extinction discourse. It is arguably the main reason the subject of extinction has attained such rhetorical power over the past fifty years. For example, the US Fish and Wildlife Service championed the Endangered Species Act in the 1970s using the slogan "Extinct is Forever" (Roosth 2017). However, this famous mantra is being challenged. The question is now being asked whether extinction is, in fact, necessarily forever. Due to advances in genetics and synthetic biology, there now appears to be a plausible pathway for reviving species that have been extinct for several decades, centuries, or even millennia. Preserved DNA from the bones and feathers of museum specimens theoretically makes possible the de-extinction of creatures driven to biological disappearance by human activities. This includes animals such as the woolly mammoth, the Tasmanian tiger, the passenger pigeon, and the dodo (Evans Ogden 2014).

However, de-extinction is no longer speculative. It has already taken place, if only for 7 minutes, with a species of wild goat called the bucardo, *Capra pyrenaica pyrenaica*, that once roamed the mountains of the Iberian Peninsula. The bucardo was declared extinct in 2000 after a falling tree in the Ordesa National Park in northern Spain killed the last known individual, a female named Celia. Scientists had collected and frozen ear scrapings from this sole survivor before her death. Three years later, in the summer of 2003, her clone was brought to life by fusing her somatic cells with denucleated egg cells from a domestic goat, which served as her surrogate mother. Not only was this the first extinct animal species brought back to life, but it was also the first species to go extinct twice. The resulting baby bucardo died minutes after birth, asphyxiating from lung defects (Folch 2009).

Some conservationists think de-extinction offers an optimistic and creative research agenda compared to the conventional approaches of mitigating, managing and documenting loss. It has the potential to change conservation strategies dramatically and seems almost certain to do so. As Donlan (2014) suggests, there are many unknowns surrounding de-extinction, but whether it will happen is not likely to be one of them. The central practical issue will unlikely be the recreation of the species themselves - advances in synthetic biology seem inevitable in the very near future. The challenge is more about where the resurrected animals go. Humans are becoming experts in manipulating genomes but learning how to create appropriate habitats for the new species to be reintroduced into is another matter.

IMAGE 5.1 The bucardo – the first extinct animal species brought back to life
Artist: Wolf, Joseph (1898), reproduced from Wikipedia (2022)

For some, de-extinction is a contentious subject that merits examination from scientific, ethical, legal, and economic perspectives. The principal ethical concerns are its unnaturalness; it could cause animal suffering (such as with the short-lived baby bucardo); it could be ecologically problematic or detrimental to human health, and it is hubristic or akin to 'playing God'. Advocates have suggested several ethical considerations in favour of pursuing it: it is a matter of justice; it would re-establish lost value; it would create new value; and we need it as a conservation last resort (Sandler 2013). It is a complex subject where it is not easy to formulate responses to questions it asks. As Grinspoon (2017) ponders: if fifty years from now, there are no Siberian tigers, but we could create a family of them, should we?

Whether researching de-extinction, undertaking ethnographic work, exploring scale and ethical issues, or developing work from individual chapters, there is much potential for continued research on extinction, particularly within anthropology, which is a newcomer to some of the debates. This thesis, it should be apparent, barely scratched the surface and, to my mind at least, has generated more questions than answers. These questions, I believe, can help develop and perhaps reimagine better questions and approaches to extinction, hopefully to the overall benefit of planetary life now and in the future.

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