

An essay for the Eon Essay Contest 2022, in response to *The Precipice: Existential Risk and the Future of Humanity*, by Toby Ord

22+ Age Bracket: “What, according to you, is missing from this book? This missing piece can be data, analysis, or an argument. The missing piece can either strengthen or weaken a conclusion from the book.”

The ‘Butterfly Effect’ and ‘Boiling Frog’ Phenomenon:

Ensuring a Habitable Earth for an Eon

Author name removed

Every man must decide whether he will walk in the light of creative altruism or in the darkness of destructive selfishness. This is the judgement. Life’s most persistent and urgent question is, what are you doing for others? – Martin Luther King Jr.¹

Of course, the benefits of such actions will not be there to enjoy for all of us here today: we none of us will live forever. But we are doing this not for ourselves but for our children and our children’s children, and those who will follow in their footsteps. – Queen Elizabeth II, addressing the 26th UN Climate Change Conference in 2021.²

¹ Quoted in Matthieu Ricard, *Altruism: The Power of Compassion to Change Yourself and the World*, (New York: Little, Brown), introduction.

² ‘The Queen’s speech at the COP26 Evening Reception’, <<https://www.royal.uk/queen%E2%80%99s-speech-cop26-evening-reception>>

As Toby Ord's *The Precipice* identifies, the availability heuristic can inhibit management of existential risks.³ This essay strengthens this warning by showing how other biases could limit mitigation against climate change, and related environmental damage, hereafter 'ecocide'.⁴ First, I offer a conceptual analysis of the Earth as a fragile 'chaotic system', to illustrate the risk of how our interactions with it could jeopardise humanity's progress and longterm potential.^{5 6}

In the 1960s, Edward Lorenz, Ellen Fetter, and Margaret Hamilton combined mathematics and meteorology to predict the weather.⁷ When the decimal points in their formulas were truncated, the resulting predictions progressively deviated from what they would have been without the initial error.⁸ This 'butterfly effect'⁹ is why weather patterns become increasingly unpredictable, because they are sensitive to initial marginal errors, whose effects increase over time. Significantly, shortly after 'chaos theory' emerged, Lorenz pointed out the 'chaotic nature' of the climate system itself, as well as 'the possibility of sudden shifts' attributable to human activity.¹⁰

³ Toby Ord, *The Precipice: Existential Risk and the Future of Humanity*, (London: Bloomsbury, 2020), p. 61. 'This is a tendency for people to estimate the likelihood of events based on their ability to recall examples', such that we underestimate the probability of unprecedented events, and overestimate the probability of events similar to ones we remember. There has not been an existential catastrophe in living memory (although there have been close calls in the past century, the Cuban Missile Crisis, for example).

⁴ Ord, pp.112-119.

⁵ Ord, p. 37.

Longterm potential, defined as 'the set of all possible futures that remain open to us[...] including everything that humanity could eventually achieve'.

⁶ Certainly on a local level (for example, low-lying islands) the existential risk, as defined, is considerably higher, due to the potential for rising sea levels.

Heather Lazrus and Carlos Arenas, 'Islands on An Angry Earth: Climate Change, Disasters, and Implications for Two Island Communities' in *The Angry Earth, Disaster in Anthropological Perspective*, ed. Anthony Oliver-Smith and Susanna M. Hoffman, (London: Routledge, 1999), p. 1312;

Noami Klein, *This Changes Everything*, (London: Random House, 2014), pp.12-14.

⁷ Joshua Sokol, 'The Hidden Heroines of Chaos', *Quantum Magazine*, 20 May 2019, <<https://www.quantamagazine.org/the-hidden-heroines-of-chaos-20190520/>>

⁸ Edward Lorenz, *The Essence of Chaos*, (Seattle: University of Washington Press, 1993), pp.134-136.

⁹ Butterfly effect: 'The phenomenon that a small alternation in the state of a dynamical system will cause subsequent states to differ greatly from the states that would have followed without the alteration.'

Edward Lorenz, *The Essence of Chaos*, (Seattle: University of Washington Press, 1993), p.206.

A representation of the 'butterfly effect' is figure 2 in Lorenz's *The Essence of Chaos*, p. 14.

¹⁰ Christopher Cumo and Fernando Herrera, 'Chronology', *Encyclopaedia of Global Warming and Climate Change*, (ed. George Philander), P.xxxviii.

There is a range of estimates of the severity of global warming, one of many factors of climate change.¹¹ Models are simplifications, but can be useful for our understanding.¹² Thus, the purpose of conceptualising the Earth as a ‘chaotic system’ is not to predict the trajectory of the climate, but rather to help our comprehension of how continued ecocide could amount to an existential risk in the future.¹³ There would not be one single existential catastrophe, but rather a build up of events amounting to an existential catastrophe. Whilst acknowledging the specific risks, we should also consider the ‘difficulty of seeing the risk to the system as a whole’. This fallibility was, in hindsight, a cause of the 2008 ‘credit crunch’.¹⁴ Comprehending the risk of ecocide to the Earth system as a whole is a prerequisite to preventing a catastrophe of a considerably greater scale.¹⁵

The Earth is not passive.¹⁶ Rather, it is a reactive entity, composed of interlinked complex parts,¹⁷ each of which have increasing sensitive dependence to external, anthropological inference.¹⁸

¹¹ Simon Beard et al., ‘Assessing climate change’s contribution to global catastrophic risk’, *Futures*, 21 (2021), <doi.org/10.1016/j.futures.2020.102673> pp.2-3.

¹² Tamsin Edwards, *How to love uncertainty in climate science*, [video] TED Conferences, 29 October 2014, <<https://www.youtube.com/watch?v=RP5nhmp06xs>>

Lorenz, in *The Essence of Chaos*, (p.210), defines a model as ‘A system designed to possess some of the properties of another, generally more complicated, system’.

¹³ Nick Bostrom, ‘Existential Risk Prevention As Global Priority’, *Global Policy*, 4 (2013), <<https://existential-risk.org/concept/>>, pp. 15-16

¹⁴ Tim Besley and Peter Hennessey, ‘The Global Financial Crisis - Why Didn’t Anybody Notice?’, *British Academy Review*, 14 (2009), <<https://www.thebritishacademy.ac.uk/documents/733/03-Besley.pdf>> 8-10.

¹⁵ Ord (p.61) defines ‘scope neglect’ as ‘a lack of sensitivity to the scale of a benefit or harm. We have trouble caring ten times more about something when it is ten times as important’.

¹⁶ James Lovelock, *The Vanishing Face of Gaia: A Final Warning*, (New York: Perseus, 2009), p.6; p.22.

¹⁷ Complexity is can be defined in two slightly differing ways, ‘sensitive dependence and everything that goes with it’, or more commonly as ‘the length of a set of instructions that one would have to follow to depict or construct a system’ (Lorenz, *The Essence of Chaos*, p. 167).

This complexity is increased by the fact that the Earth is composed of interlinked complex systems of the biosphere, atmosphere, cryosphere (frozen water part of the earth system), and lithosphere (the rocky outer surface of the earth, where a decreasing amount of fossil fuels reside).

¹⁸ In *The Essence of Chaos*, Lorenz (p.207) defines Chaos as ‘1. The property that characterises a dynamical system in which most orbits exhibit sensitive dependence; full chaos. 2. Limited chaos; the property that characterizes a dynamical system in which some special orbits are non periodic but most are periodic or almost periodic.’

The interdependent relationship between humanity and the Earth¹⁹ may be characterised as a two-way chaotic system. The abilities of both human society and the Earth to survive are sensitively dependent²⁰ upon the initial conditions of the other. External anthropological damage to the environment, such as an erosion of finite resources of the Earth,²¹ has persisted in recent decades.²² Continued ecocide can be seen as an error in two ways: firstly, as a literal mistake (as it is contrary to what we know is the sustainable ideal); and secondly, as a marginal error that could, over time, via butterfly effects, increase the risk of ‘extinction or irrevocable collapse.’²³ In chaos theory, a permanent increase in a constant (for example, average global temperatures²⁴) causes an irreversible alteration in the long-term behaviour of a system.²⁵ ‘Tipping points’²⁶ could trigger unprecedented shifts in Earth system behaviours, such as the frequency and magnitude of natural hazards, and higher wet bulb temperatures, making outdoor work ‘intolerable’.²⁷

¹⁹ Dipesh Chakrabarty, ‘Climate and Capital: On Conjoined Histories’, *Critical Inquiry*, 41 (2014), <<https://doi.org/10.1086/678154>>, p.20. Chakrabarty sees the climate crisis as straddling both human and natural history.

²⁰ In *The Essence of Chaos*, (p.212), Lorenz defines Sensitive Dependence as ‘The property characterizing an orbit if most other orbits that pass close to it at some point do not remain close to it as time advances’

²¹ Fred Pearce, *When the Rivers Run Dry: What Happens when Our Water Runs Out?* (London: Transworld Publishers, 2006)

²² As Paul Crutzen and Will Steffen put it, from 1950 ‘human activities rapidly changed from merely influencing the global environment in some ways to dominating it in many ways. Paul J. Crutzen & Will Steffen, ‘How Long Have We Been in the Anthropocene Era?’, *Climate Change*, 61 (2003), p. 253.

²³ Ord, p.110.

²⁴Michelle T. Dvorak, Kyle C. Armour, Dargan M.W. Frierson, et al., ‘Estimating the timing of geophysical commitment to 1.5 and 2.0 °C of global warming’, *Nature Climate Change*, (2022) <<https://doi.org/10.1038/s41558-022-01372-y>>

²⁵ Bifurcation: ‘In a family of dynamical systems, an abrupt change in the long-term behavior of a system, when the value of a constant is changed from below to above some critical value.’ Edward Lorenz, *The Essence of Chaos*, (Seattle: University of Washington Press, 1993), p.206.

²⁶Klein, p. 412.

²⁷ Steven Sherwood and Matthew Huber, ‘An adaptability limit to climate change due to heat stress’, *Proceedings of the National Academy of Sciences*, 107 (2010) <<https://doi.org/10.1073/pnas.0913352107>>

With mathematics, the extent of the butterfly effect can be calculated by comparing formulas. Yet in the real world, evaluating the effects of ecocide requires us to consider mutually exclusive counterfactuals, and estimate what *might* happen if a strategy or policy is not enacted.²⁸ These mental processes use advancements from the pre-agricultural Cognitive Revolution, which made it possible to communicate imagined scenarios as well as immediate danger.²⁹ Communicating existential risk today is still vulnerable to various cognitive biases. These fallibilities may inhibit mitigation,³⁰ and may counteract humanity's 'resilience and adaptability',³¹ as well as nature's. As Naomi Klein asked, 'what is wrong with us?'³²

Certainly, a failure of mitigation would be a cause of catastrophes if they occur.³³ To eliminate,³⁴ or at least decrease, the risk of ecocide in the longer term, the mitigation is primarily preventative, such as regulation or alternative, sustainable investment.³⁵ Slowing the rise of sea levels requires the phase out of fossil fuel plants to be undertaken on a yet greater scale than the decommissioning of some nuclear reactors.³⁶

²⁸ As Lorenz himself pointed out, 'The atmosphere is not a controlled laboratory experiment; if we disturb it and then observe what happens, we shall never know what would have happened if we had not disturbed it.' Lorenz, Edward, (1972, December 29) Predictability: Does the Flap of a Butterfly's Wings in Brazil Set off a Tornado in Texas? [Paper presentation]. 139th Meeting American Association for the Advancement of Science. Sheraton Park Hotel, Boston, Massachusetts. <https://eapsweb.mit.edu/sites/default/files/Butterfly_1972.pdf>

²⁹ Yuval Noah Harari, *Sapiens: A Brief History of Humankind*, (London: Penguin, 2011), pp.23-27.

³⁰ Mitigation action, especially defined as prevention, to 'avoid [a risk's] origin', and response, to 'limit its scaling', as per Ord's categorisation on p. 172

³¹ Beard et al. <<https://doi.org/10.1016/j.futures.2020.102673>>, p.3.

³² Klein, p.15.

³³ Beard et al, <doi.org/10.1016/j.futures.2020.102673> p. 4.

³⁴ That is, if we are to move towards making a global catastrophic risk arising from environmental damage a probability of zero. An impossibility itself may be impossible. As Edward Lorenz wrote in *The Essence of Chaos*, mathematicians would say that hitting the corner exactly of a square dartboard has a probability of zero, yet, 'Clearly, however, a zero probability is not the same thing as an impossibility; you are just as likely to hit any particular point on the diagonal as any particular point elsewhere' (p. 21). Therefore, we may never be able to say that a global catastrophic risk from ecocide is impossible, but it could have a probability of zero. The dartboard's diagonal edges, as a metaphor representing the existential risk of ecocide, have been slowly broadening in recent years, and we need to make them narrower.

³⁵ Bernice Lee, 'Climate change: The only option is action', *Chatham House, The World Today*, 27 March 2022, <<https://www.chathamhouse.org/publications/the-world-today/2022-06/climate-change-only-option-action>>

³⁶ Fred Pearce, *Fallout: Disasters, Lies, and the Legacy of the Nuclear Age* (Boston: Beacon Press, 2018), pp.186-191.

Considering the above, we ought to be aware of the biases that can inhibit, as Barack Obama put it, ‘translating concern into action’.³⁷ As we have seen, the Earth’s reactions to anthropogenic damage are cumulative, causing disturbances to both natural and societal systems that are increasingly unpredictable.³⁸ These present catastrophic risks that are, as Karin Kuhlemann shows, ‘boiling frog’ phenomena, as they grow gradually, so their evident urgency is less perceived.³⁹ This bias is perhaps the most pernicious, as the less the risk is perceived, the less likely mitigation becomes, and the more the risk may increase.⁴⁰ How else might we fail to mitigate?

As well as distraction,⁴¹ polarisation may also hinder mitigation, and accepting responsibility for addressing existential risks. Amidst the uncertainty, scale and relative remoteness of ecocide, and its habitual nature, the least difficult default is to leave responsibility to others.⁴² Whilst democracies are ever more divided and divisive, risk assessments can appear clouded alongside policy proposals, in part due to ‘the misunderstanding and misrepresentation of uncertainty’ in society.⁴³ As Simon Beard from the Cambridge Centre for the Study of Existential Risk has observed, people responding to their work – or perhaps the most vocal – tend to fall into

³⁷ The New York Times, *Exclusive Obama Interview on ‘Terrifying’ Threat of Climate Change*, 8 September 2016, [video], <<https://www.youtube.com/watch?v=RP5nhmp06xs>>

³⁸ David Wrathall et al. ‘Problematizing loss and damage’, *International Journal of Global Warming*, 8 (2015), p.278.

³⁹ Karin Kuhlemann, ‘Complexity, creeping normalcy and conceit: sexy and unsexy catastrophic risks’, *Foresight*, 21 (2019), <<https://doi.org/10.1108/FS-05-2018-0047>> p. 42.
‘These are “boiling frog” phenomena that play out in slow motion – at least as perceived by humans [...] Even where we recognise that something is a problem, we may still not recognise the underlying, catastrophic trendline, or just how much damage is already baked into states of affairs that we come to regard as normal.’

⁴⁰ Inadequate communication can hinder mitigation action in democracies, this is discussed further in Catherine Happer, ‘Belief in Change: The Role of Media and Communications in Driving Action on Climate Change’, in Alexander Elliot et al. (eds.) *Climate Change and the Humanities: Historical, Philosophical and Interdisciplinary Approaches to the Contemporary Environmental Crisis*, (London: Palgrave Macmillan, 2017), 177-197.

⁴¹ Ord, p.60.

⁴² Bari, Shahidha, ‘Existential Risk’ in BBC Radio 4 Arts and Ideas, <<https://www.bbc.co.uk/sounds/play/p0bnlxql>> 10 February 2022. 10 minutes in.

⁴³ Tamsin Edwards, *How to love uncertainty in climate science*, [video] TED Conferences, 29 October 2014, <<https://www.youtube.com/watch?v=RP5nhmp06xs>>

two camps: of Panglossian optimists, and pessimists who feel we're already doomed.⁴⁴ This dichotomy is perhaps reflected in the polar perspectives of 'it's too late' and 'it's not too late'.⁴⁵ In reality, preventative measures are likely to be less effective over time (infrastructure such as flood defences can take decades to build⁴⁶). This time lag makes the potential butterfly effects from ecocide more uncontrollable. However, the generic belief in technical solutions may lead us to underestimate the overall risk.⁴⁷ Rather than panic or apathy, the best collective approach is characterised by pragmatic anxiety.

So far, 'mitigation' has been concerned with prevention and response. Disaster agencies may not be able to prevent existential catastrophes, but they could be crucial in ensuring resilience,⁴⁸ potentially by protecting a 'minimum viable population'.⁴⁹ However, as per the butterfly effect, errors in disaster management could cause greater repercussions. Decision-making can be subject to ego.⁵⁰ Recent expertise does not necessarily translate into current policy by those in positions of responsibility.⁵¹ For complete mitigation against the risk of ecocide, we must consider institutional as well as individual psychology.

⁴⁴ Bari, Shahidha, 'Existential Risk' in BBC Radio 4 Arts and Ideas, <<https://www.bbc.co.uk/sounds/play/p0bnlxql>> 10 February 2022. 8-9 minutes in.

⁴⁵ Paul Davies, 'Investment Without Return: On Futures That Will Never Be Ours', in Elliot, Alexander et al. (eds.) *Climate Change and the Humanities: Historical, Philosophical and Interdisciplinary Approaches to the Contemporary Environmental Crisis*, (London: Palgrave Macmillan, 2017), pp.223-226

⁴⁶ Sari Kovats et al. 'London, United Kingdom' in Sheridan Bartlett and David Satterthwaite, (eds.) *Cities on a finite planet: Towards transformative responses to climate change*, (Oxford: Routledge, 2016), p.125. 116-134

⁴⁷ Karin Kuhlemann, p. 46.

⁴⁸ Resilience, defined as the third type of mitigation action, to thwart the endgame of a global catastrophe. Ord, pp.171-172.

⁴⁹ Ibid, p.41.

⁵⁰ Jane M. Thomas, 'Disaster Theory versus Practice? It is a Long Rocky Road: A Practitioner's View from the Ground', in *Disaster Upon Disaster: Exploring the Gap Between Knowledge, Policy and Practice*, ed. Susanna Hoffman and Roberto E. Barrios (New York: Berghahn Books, 2020), p.316

⁵¹ Susanna Hoffman, 'Defining Disaster Upon Disaster: Why Risk Prevention and Disaster Response so Often Fail', in *Disaster Upon Disaster: Exploring the Gap Between Knowledge, Policy and Practice*, ed. Susanna Hoffman and Roberto E. Barrios (New York: Berghahn Books, 2020), pp.15-17.

Thales of Miletus thought that the world's fundamental matter was water, because of its necessity for life, its ubiquity, and its transformative ability into different states.⁵² There is an anecdote that he tripped and fell into a ditch, whilst looking up at the stars of the night sky. (Thales' stumble is an example of the butterfly effect: a small footing error led to larger repercussions for the body.⁵³) Someone went to help him and said, 'How can you expect to know all about the heavens, Thales, when you cannot even see what is just before your feet?'⁵⁴ Thales fell because he looked too far; he was the opposite of myopic. In the present precipice, humanity must lift its sights further ahead in order to mitigate against the accumulation of risk to the Earth and to ourselves. Only then can we ensure there exists a habitable Earth for the 'Anthropocene' and beyond.⁵⁵

Word count: 1198.

⁵² Lewis Wolpert, *The Unnatural Nature of Science*, (London: Faber and Faber, 1992), p.35.

⁵³ This is a very broad and non-mathematical, example. In the 1993 film *Jurassic Park*, character Dr. Ian Malcolm explains chaos theory by seeing which way a drop of water on a hand will trickle.

⁵⁴ Diogenes Laertius, *Lives of the Eminent Philosophers*, <https://www.loebclassics.com/view/diogenes_laertius-lives_important_philosophers_book_i_chapter_1_thales/1925/pb_LCL184.35.xml>, translated by Robert D. Hicks, p.35.

⁵⁵ Action to mitigate against ecocide is necessary, but not sufficient, to realise the 0.5 probability, that Ord estimates, of every global catastrophe. (Ord, p. 169.) This estimation of a 0.5 probability undoubtedly factors in, and thus avoids, the availability heuristic.

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