Environmental futures, now and then: crisis, systems modelling and speculative fiction

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Abstract Post-war environmental concern has been powerfully shaped by projections of ecological catastrophe. Indeed, it can be said that the global environment as an object of social and political concern came into existence in part through narratives of future crisis. This paper explores two successive framings of environmental crisis and the kinds of knowledges that made them up. It examines the announcement of ecological limits to economic growth in the early 1970s, the culmination of an early wave of popular green concern that modelled the future as a choice between the catastrophic continuation of business as usual and the prospect of eco-utopian alternatives. It considers the crisis logics of contemporary climate dynamics, where the power of scientific modelling leaves little room for the imagination of radically different futures. Environmental crisis now cannot perform the anticipatory and utopian functions that it once did. The 'apocalyptic horizon' (Dryzek) of limits has given way to the collapse of crisis into the present and new kinds of colonisation of the future. But in both cases environmental crisis can be read as a science fictional object, simultaneously descriptive and speculative, scientific and fictional. Science fiction tropes were crucial to early constructions of environmental crisis, and speculative climate fiction will be a vital resource for negotiating the social-natural futures of the Anthropocene.

The idea of environmental crisis

For the past 50 years, from the limits to growth in the 1970s to climate change today, environmental concern has been shaped by projections of potentially catastrophic disruption to ecological and economic systems. Indeed in many ways the idea of the global environment as an object of social and political concern does not exist without narratives concerning the "crisis about its future."[2] As Ross has argued, of all the new social movements of the 1960s and 1970s "the ecology movement was the one most tied to an explicit set of theses about the future: how

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[2] Libby Robin, Sverker Sörlin and Paul Warde, "Introduction: Documenting Global Change" in *The Future of Nature: Documents of Global Change*, edited by Libby Robin, Sverker Sörlin and Paul Warde (New Haven, CT: Yale University Press, 2013), 6-7.

to avoid a disastrous, and generate a better, future."[3] In this paper I explore the kinds of knowledges that have made up successive ideas of environmental crisis and environmental futures. I focus in particular on the relationship between techno-scientific projections and wider cultural repertoires of speculation: between environmental science and green science fiction; between predictions of ecological catastrophe and dreams of better futures with and for nature.

Environmental crisis is closely linked to claims to scientific certainty, predictive statements and policy expertise. As Robin et. al. put it, "[t]he Age of Environment has been nurtured by the Era of Prediction."[4] But both have also been deeply entangled with speculative and fictional imaginaries that raise ethical, political and even metaphysical questions about human prospects in a changing natural world. Ideas of environmental crisis since the 1970s have been composed of varying admixtures of systematic and self-consciously objective attempts to model eco-social future trajectories on one hand, and heuristic and affective future imaginaries on the other. In this respect environmental concern typifies the sometimes synergistic and sometimes sterile tension between technocratic extrapolation and humanist utopianism that Andersson identifies at the core of the post-war project of futures studies.[5] Understanding science and speculation together offers a rich picture of the history of contemporary environmental ideas and a nuanced understanding of what has changed in crisis narratives between the 1970s and the present day, both in terms of the scientific epistemologies that make up crisis, and in terms of the work that crisis does on and in the popular and political imagination.

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[3] Andrew Ross, *Strange Weather: Culture, Science and Technology in the Age of Limits* (London: Verso, 1991), 184.
[4] Robin et. al. "Introduction," Preface.
[5] Jenny Andersson, "Midwives of the Future: Futurism, Futures Studies and the Shaping of the Global Imagination," in *The Struggle for the Long Term in Transnational Science and Politics: Forging the Future,* edited by Jenny Andersson and Egle Rindzeviciute (London: Routledge, 2015); Jenny Andersson, "The Great Future Debate and the Struggle for the World," *The American Historical Review* 117, no. 5 (December 2012); Jenny Andersson and Sibylle Duhautois, "Futures of Mankind: the Emergence of the Global Future," in *The Politics of Globality Since 1945: Assembling the Planet,* edited by Rens Van Munster and Casper Sylvestre (London and New York: Routledge, 2016); see also Ross, *Strange Weather*.

With that in mind I work through two arguments in this article. The first is that environmental crisis now is not the same as environmental crisis then. In the 1970s ecological crisis usually took the form of a future projection based on highly abstract models of large-scale global systems. The idea of crisis in this period introduced a shocking and novel "apocalyptic horizon"[6] into modern Western imaginaries of progress and the future, and as such it opened up debates about radically different alternatives: apocalypse or utopia; economic business as usual or an ecology for people and planet; heedless progress or mindful stability; collapse or sustainability. Today, environmental crisis is no longer a novelty. We are effectively living through what Wynne calls the "predictive shadow"[7] of the first announcement of impending crisis. Buell argues that environmental apocalypse now feels something more like "a way of life"[8] than a projection. The present is saturated with slowly unfolding environmental collapse, and the future is colonised by warming mechanisms already in train. In these circumstances, the idea that the prospect of crisis might stimulate radical social change can seem much less tangible. In what follows I focus on some of the contrasts between the projection of environmental crisis under the sign of the limits to growth in the 1970s, and the idea of climate crisis as a public, cultural and technoscientific object after the publication of the Intergovernmental Panel on Climate Change (IPCC) 4th Assessment Report in 2007.[9]

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[6] John S. Dryzek, *The Politics of the Earth: Environmental Discourses* (Oxford: Oxford University Press, 1997), 37.

[7] Brian Wynne, "Strange Weather, Again: Climate Change as Political Art," *Theory, Culture and Society* 27, nos. 2-3 (2010): 298.

[8] Frederick Buell, *From Apocalypse to Way of Life: Environmental Crisis in the American Century* (New York, Routledge, 2003).

[9] Intergovernmental Panel on Climate Change (IPCC) *Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Core Writing Team, Pachauri, R.K and Reisinger, A. (eds.)], (IPCC, Geneva, Switzerland, 2007).

My second argument is that environmental crisis can productively be read as a science fictional object, that is, as an epistemic entity composed of orientations to planetary futures that are at once descriptive and speculative, scientific and fictional. I base this argument in part on a theoretical claim about the nature of the science fictional imagination and the distinctive position of the genre as "the literature of technoscientific societies."[10] I understand science fiction after Csicsery-Ronay as a cultural sensibility that emerged over the course of the 20th century in response to intense scientific and technological change. Its fictional mode combines extrapolative and cognitive mapping of technoscientific innovation with socio-political and ethical critique of likely outcomes. This sensibility helped make environmental crisis thinkable. My argument also involves the more specific suggestion that popular scientific framings of environmental crisis in the 1960s and into the early 1970s drew extensively on science fiction tropes, rhetorics, icons and narratives already in cultural circulation. In this sense the scientific and the science fictional were constitutively entangled in making up the environmental crisis as a matter of public and political concern. As we grapple now with a present and a future being rapidly reshaped by climate dynamics, science fiction is doing vital work examining the prospects for a liveable Anthropocene, even generating new ways of thinking about the possibility of a better one.

The science fictionality of environmental crisis

In histories of modern environmentalism the announcement of ecological crisis in the 1960s and 1970s is seen as a critical moment.[11] In this telling, crisis is understood as political and

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[10] Istvan Csicsery-Ronay Jr., *The Seven Beauties of Science Fiction* (Middletown, CT: Wesleyan University Press, 2008).

[11] Selective examples include Andrew Dobson, *Green Political Thought* (London: Routledge, 2007, 4th ed.); Robyn Eckersley, *Environmentalism and Political Theory Towards an Ecocentric Approach* (New York: State University of New York Press, 1992)*; Samuel Hays, *Beauty, Health, and Permanence: Environmental Politics in the United States, 1955–1985* (Cambridge: Cambridge University Press 1989); David Pepper, *The Roots of Modern Environmentalism* (London: Routledge, 1984); Douglas Torgerson, *The Promise of Green Politics*: Environmentalism and the Public Sphere (Durham, N.C: Duke University

metaphysical: a means of making a radical intervention into the politics of unsustainability, challenging humanity to reject exploitative and destructive capitalism and pursue a more sustainable life in touch with nature. More recently, in histories of science and STS, the focus has been how systems modelling and the cybernetic sciences helped to create the idea of planetary crisis - and how in turn the prospect of system collapse helped to construct emerging discourses of globality and planetary environmental management.[12] In this telling, environmental crisis is a product of shifts in the co-production of scientific knowledge in the middle of the 20th century, or appears as a crisis in objectivity revealing the hybridity of social, natural and technological systems, and an opportunity to reimagine the politics of nature.[13]

Both environmental histories and STS accounts touch on the links between environmentalism and science fiction. Environmental histories often identify Rachel Carson's *Silent Spring* as a foundational text, especially the opening chapter with its powerfully apocalyptic image of a future American small town leached of life by chemical pesticides and pollution. STS studies touch on some of the science fiction texts that accompanied the announcement of environmental crisis in the 1960s and 1970s, in particular the dystopian narratives of overpopulation and pollution that formed part of the trope or metaphor of "spaceship earth"[14] that Hohler argues was critical to the emergence of discourses of planetary management. But

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Press, 1999); Donald Worster, *Nature's Economy: A History of Ecological Ideas* (Cambridge: Cambridge University Press, 1985, 2nd ed.). These histories also make clear that the making of modern environmental thought involved the recovery and recontextualization of earlier 19th and 20th century writers who emphasised not crisis but conservation, living in place, and romantic accounts of nature's intrinsic value – Rachel Carson, Aldo Leopold, John Muir, Henry David Thoreau. See for example Worster, *Nature's Economy*, 342-356.

[12] Sabine Höhler, *Spaceship Earth in the Environmental Age, 1960-1990* (London: Routledge, 2016). Fernando Elichirigoity, *Planet Management: Limits to Growth, Computer Simulation, and the Emergence of Global Spaces* (Evanston, IL: Northwestern University Press, 1999). See also Andersson and Duhautois "Futures of Mankind."

[13] Bruno Latour, *Politics of Nature: How to Bring the Sciences into Democracy* (Cambridge, MA: Harvard University Press, 2004).

[14] Höhler, *Spaceship Earth*.

few studies have looked systematically at the changing relationship between science fiction and environmental crisis since the 1970s or drawn on the resources of science fiction literary criticism to do so. Accounts that *have* explored the nexus of science fiction and environmental rhetoric have focused almost exclusively on dystopian and (post-) apocalyptic narratives[15] at the expense of exploring the strands of utopian thinking that have been such an important part of modern environmental thinking. To understand environmental crisis, then, we need to understand its historical emergence at the intersection of politics, fiction and science as well as its changing cultural functions in mobilising debates about ethical and social alternatives - including both apocalyptic visions and intimations of better futures with nature that would be sustainable, satisfying and equal.

Approaching the environmental crisis through the lens of science fiction is a way of exploring the history of environmental ideas across varied epistemic claims and multiple knowledge contexts. It offers new insights into how ecopolitical ideas emerged from a cultural backdrop rich in science fictional tropes, and how environmental modelling has been taken up and elaborated in genre literature. I will sketch some of the specificities of these intertextual connections in what follows. But I also want to suggest a more fundamental and general way in which the science fictional imagination has played a constitutive part in the very idea of environmental crisis. Cscisery-Ronay argues that over the course of the 20th century science fiction literature and its ideas have saturated modern Western cultures. This makes possible a "mood," "habit of mind" or "kind of awareness"[16] that is powerfully alert to the constant

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[15] Buell, *From Apocalypse to Way of Life*; Ross, *Strange Weather*; M. Jimmie Killingsworth and Jacqueline S. Palmer, "Millennial Ecology: The Apocalyptic Narrative from Silent Spring to Global Warming," in Green Culture: Environmental Rhetoric in Contemporary America, edited by Carl G. Herndl and Stuart C. Brown, Madison WIS, University of Wisconsin Press, 1996, pp.21-45; M. Jimmie Killingsworth and Jacqueline S. Palmer, "*Silent Spring* and Science Fiction: An Essay in the History and Rhetoric of Narrative," in *And No Birds Sing: Rhetorical Analyses of Rachel Carson's Silent Spring*, edited by Craig Waddell, Carbondale and Edwardsville, Southern Illinois University Press, 2000, 177.
[16] Csicsery-Ronay, *Seven Beauties*, 2-3.

emergence of technoscientific novelty and which offers a toolkit of tropes, metaphors, icons and narratives for speculating about the futures and social forms that those innovations might bring about. The science fictional imagination is about the pleasures of playing in and with those possible futures. It also involves a distinctive attitude of estrangement and critique: a way of stepping back from how things are and from the apparent certainties of prospective scientific knowledge claims in order to enact what Csicsery-Ronay calls a double hesitation: a pause in which the critical imagination is mobilised to interrogate what is plausible, and to consider what is ethical or desirable.

The very idea of environmental crisis involves a kind of science fictional imagination. It involves being able to apprehend the earth, its ecosystems and socio-economic arrangements as a single entity, viewed from outside. It involves being able to project a common future for humanity over a 100-year timescale. Modern environmentalism has always depended on projected planetary futures to make its case, and those futures have always been in the most basic of senses fictional: imagined, created, narrated. They have been *science* fictional insofar as they partake of science fiction's extrapolative critique of technoscience. It is not a coincidence that modern environmentalism emerged contemporaneously with a major shift in science fiction: from being a genre largely celebratory of scientific futurism and technocratic models of progress (peaking in the early 1950s[17]) to, by the early 1970s, one increasingly critical of the powers of technoscience and alienated from the supposed benefits of Western modernity. Both have offered images of overcrowded cities; burning, drowning and drying worlds; angry protagonists fighting back against despair. Dystopian science fiction from the 1950s to the 1970s, in the novels of J G Ballard, John Wyndham, Frank Herbert, Ursula K Le

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[17] Specifically 1953, according to Thomas M. Disch, "On Saving the World," in *The Ruins of Earth*, edited by Thomas M. Disch (London: Hutchinson and Co, 1973), 9.

Guin, Phillip K Dick, John Brunner and Harry Harrison, both anticipated and reflected environmentalist themes of pollution, overpopulation, limits to growth and widespread alienation.[18]

In this period an emergent environmentalism and a changing science fiction were operating together to map and contest the globalising hubris of military-capitalist technoscience. They did so in the shadow of the bomb and the threat of nuclear catastrophe. Worster dates the "age of ecology" to the first atomic explosion in 1945, the consequences of which included widespread "doubt" about "the entire project of the domination of nature that had been at the heart of modern history, "the moral legitimacy of science, the tumultuous pace of technology."[19] Thomas Disch, editing an early collection of science fiction short stories about environmental crisis in 1971, also makes this connection by characterising ecological destruction as "bombs" that are "already dropping."[20] Today's crisis is not shaped by not only by different substantive threats but by a different logic: of chronic, ongoing and well-known environmental dynamics, including the logics of climate change that are already in train. Science is now better at mapping threats and modelling likely futures; but critical and imaginative political and social thinking is more, not less, important. Science fiction continues to furnish contemporary cultures with crucial resources for imagining environmental futures.

Inventing environmental crisis: limits, science and science fiction in the 1970s

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[18] In this article my primary focus is on novel-length science fiction; science fiction film and short stories would obviously add further examples and themes to this list .

[19] Worster, *Nature's Economy*, 342, 343.

[20] "In effect the bombs are already dropping – as more carbon monoxide pollutes the air… as mercury poisons our waters, our fish, and ourselves, and as one by one our technology extinguishes forms of life upon which our own life on this planet depends." Disch, "On Saving the World," p. 11. This connection culturally is a complex one. The continuities are important – but modern environmentalist discourse is distinctive in its addition of a pervasive sense of the vulnerability of nature and a focus on crisis in interconnecting systems – see Worster, *Nature's Economy* and other useful discussions in Ross, *Strange Weather*; Buell, *From Apocalypse to Way of Life*; Killingsworth and Palmer, "Millennial Ecology," *inter alia*.

> If the present growth trends in world population, industrialization, pollution, food production and resource depletion continue unchanged, the limits to growth on this planet will be reached something within the next one hundred years. The probable result will be a rather sudden and uncontrollable decline in population and industrial capacity.[21]

In 1972 the Club of Rome published *The Limits to Growth: A Report for the Club of Rome on the Predicament of Mankind*. This widely publicised assessment of future global development aimed to show that over the next 100 years unconstrained economic growth would compromise and ultimately break the capacity of earth's ecosystems to support human life. In the fifty years since its publication, the idea of limits to growth has been dismissed as economically naïve neo-Malthusianism and green Doomsday pessimism. Its models and methodologies have been critically deconstructed, and its data has been dismissed. By the mid-1980s global policy-makers were keen to dismantle the notion of a single planetary limit to growth and frame the ecological challenge instead in terms of sustainable development and multiple development pathways.[22] But in its time *The Limits to Growth* "opened the public imaginary to the possibility of thinking anew about the relation between humanity and the biosphere."[23] It presented that relationship in term of a globally interconnected systems, remaking the planet as a unified object of technoscientific knowledge and a field for management and intervention.[24] It also provided new conceptual resources for a nascent environmental movement by holistically projecting dynamics of resource depletion, population, population growth and industrial expansion over the next century to suggest that the trajectory of industrial capitalist growth was heading inevitably towards global collapse.

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[21] Donella H. Meadows, Dennis L. Meadows, Jorgen Randers, William W. Behrens III. *The Limits to Growth: A Report for the Club of Rome's Project on the Predicament of Mankind* (New York: Universe Books, 1972), 23.
[22] World Commission on Environment and Development (WCED), *Our Common Future* (Oxford: Oxford University Press, 1987), 43. Garforth, *Green Utopias*, 40-48.
[23] Elichirigoity, *Planet Management*, 111.
[24] Elichirigoity, *Planet Management*, 7.

The Limits to Growth did not invent the idea of environmental crisis, nor was it unique in attaching environmental concerns to uncertain futures. But it did introduce a way of projecting earthly trajectories that could claim to be scientific. The World System about which *The Limits to Growth* made its arguments was not the empirical earth of geology and ecology or the sensory earth of everyday experience. It was the product of new epistemic practices that allowed the globe as an object to be seen and measured from the outside: via new technologies of visualisation, in the case of the photographic images of earth enabled by human space flight in the late 1960s and 1970s;[25] and via computer simulations constructed in the logical terms of systems theory. As has been extensively documented,[26] in *The Limits to Growth* the humanistic, existential "world problematique" of the Club of Rome met the "mathematically conceptualize[d] planet" of Jay Forrester's dynamic systems models.[27] Forrester had already used his training in post-war cybernetic sciences to simulate the future behaviours of systems including factories and cities. He had developed techniques for abstracting and quantifying complex dynamic interactions among multiple interdependent factors, in particular the positive and negative feedback loops through which systems self-regulate. In the early 1970s Forrester offered this methodology to the Club of Rome. A team led by Dennis Meadows modelled relationships among global rates of population, industrialization, pollution, food production and resource depletion, and then generated aggregated global data for each variable. Digital algorithms enabled interactions among variables to be simulated across different 'runs' over 100 years or so.

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[25] Wolfgang Sachs, "The Blue Planet: An Ambiguous Modern Icon" *The Ecologist* 24, no. 5 (1994), 170. See also Höhler, *Spaceship Earth.*
[26] Patrick W. McCray, *The Visioneers: How a Group of Elite Scientists Pursued Space Colonies, Nanotechnologies, and a Limitless Future* (Princeton and Oxford: Princeton University Press, 2013); Andersson, "The Great Future Debate"; Elichirigoity, *Planet Management*; Höhler, *Spaceship Earth.*
[27] McCray, *The Visioneers*, 29-30.

The data on world industrial development, resource use, pollution and so on that fed the World System model had to be conceptualized and aggregated from multiple incommensurate sources. As Elichirigoity points out, the model in effect created the global data rather than vice versa.[28] The Club of Rome's aim was to "represent real world relationships pictorially or mathematically," with the emphasis on visual simplicity and ease of understanding. [29] The graphs that show the World System runs in *The Limits to Growth* use vague quantities and shifting timescales. Numerical values, they admit, are "only approximately known."[30] The point is not quantitative accuracy but rather demonstrating the "relations between variables."[31] The emphasis is on the "functional interdependence" of a system constituted via "conceptual and arithmetic abstraction and simplification:"[32] "system structure and dynamics mattered far more than precise inputs."[33]

The scientific knowledge that makes up environmental crisis then was not simply a product of empirical observations but related to abstractions based on principles derived from systems theory. It is well known that Forrester's models foregrounded certain kinds of dynamic relationships, in particular logics of exponential growth and delayed feedback loops. The epistemological centrality of feedback and amplification in systems dynamics and cybernetic meant that the models almost always projected sudden and catastrophic change. They emphasised exponential growth rather than gradual or linear trajectories. The continuity of the

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[28] Elichirigoity, *Planet Management*, 90.
[29] Dennis Meadows cited in Elichirigoity, *Planet Management*, 97.
[30] Dennis Meadows cited in Höhler *Spaceship Earth*, 72. Höhler shows how the graphs in *The Limits to Growth* removed the vertical scales to bring multiple variables together on a single axis showing a multifactorial planetary catastrophe.
[31] McCray, *The Visioneers*, 30.
[32] Höhler *Spaceship Earth*, 71.
[33] Paul N. Edwards, *A Vast Machine: Computer Models, Climate Data, and the Politics of Global Warming* (Cambridge, Mass: MIT Press, 2010), 367.

current system cannot be taken for granted. Crisis is built in; the model is designed from the outset to project an impending "global emergency."[34] As Edwards argues,

> [n]o matter what they were simulating, Forrester's models tended to be insensitive to changes in most parameters […] the models offered a way to discover the few parameters and structural changes that […] would otherwise escape anyone's attempt to control them.[35]

World Systems models were designed from the outset to be about crisis and intervention rather than prediction for its own sake. *The Limits to Growth* carefully framed its futures as scenarios or projections, not forecasts. The Club of Rome expected in fact that the presence of catastrophe in the limits models would underwrite a rational argument for a planned transition to a sustainable or steady-state future.

Insisting on the possibility of the future as discontinuity, limits brought into play what had previously been an "apparently unnatural and unimaginable" prospect:[36] a no-growth economy and a society in which human wellbeing is not predicated on consumption and expansion. In this way, environmental crisis might be said to have a science fictional or utopian function. The idea of planetary limits drops a novum, a novel piece of scientific or technological knowledge, into our cognitive worlds.[37] It has the capacity to unsettle assumptions and make existing social and political arrangements seem contingent and open to change. It works through defamiliarization and the speculative imagination to distance us from everyday perceptions and understandings.[38] The progressive future in which economic growth guarantees human wellbeing and nature is used instrumentally is estranged. An ecologically sustainable alternative is made thinkable, even desirable. This articulation of environmental

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[34] The Club of Rome's Aurelio Peccei, cited in Elichirigoity, *Planet Management*, 67.
[35] Edwards, *A Vast Machine*, 367.
[36] Meadows et. al., *The Limits to Growth*, 167.
[37] Darko Suvin, *Metamorphoses of Science Fiction* (New Haven: Yale University Press, 1979).
[38] Killingsworth and Palmer, "*Silent Spring* and Science Fiction," 183.

crisis depends on a kind of science fictional imaginary that has made possible the ability to understand the earth from the outside - as a technologically transformed object and in relation to timescales outside human experience.

A key ingredient of that novum was the metaphor of "spaceship earth" that had been emerging in environmental discourse through the 1960s. As Höhler has shown, spaceship earth - our own planet "newly discovered," singular, knowable and limited[39] - is a technoscientific object. But it also depends on a science fictional metaphor that substitutes the soft planet of nature, everyday sensory experience and existential comfort with a much harder and stranger one composed of technologies, manufactured objects and limited supplies. Human space flight in the 1960s itself was itself, Höhler suggest, as much science fictional as real.[40] By 1968 piloted space flight had produced images of the blue planet, the earth seen from space, finite, fragile and unique. But the possibilities of exploration in the solar system and beyond that it opened up remained (and remain) prospective, even fantastical. The visual figure of the spaceship that frames environmental crisis discourse in the late 1960s and early 1970s then sounds scientific but derives as much from Star Trek and *Solaris* as it does from the Apollo 8 or 11 missions.[41]

In this and many other ways the idea of crisis articulated as science in the limits to growth clearly emerges from a cultural context rich in science fiction. Rachel Carson's *Silent Spring* was a crucial popular science text in the mobilisation of apocalyptic rhetorics and the

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[39] Höhler *Spaceship Earth*, 8.

[40] "already mastered […] and yet aspired to..."Höhler *Spaceship Earth*, 47.

[41] The original Star Trek seasons 1-3 were aired from 1966 to 1969. Stanislav Lem's novel *Solaris* was published in 1961 with the Tarkovsky film following in 1972. Apollo 8 in 1968 saw the earliest US moon orbits and generated the 'Earthrise' images of the blue planet seen from space. Apollo 11 was the mission of the first moon landing in 1969. The metaphor spaceship earth dates originally to the 19th century but comes to prominence in popular discourse as it was used by Kenneth Boulding in 1966 and Buckminster Fuller in 1968, and becomes an icon of environmentalism after its use by UN Secretary General U Thant on Earth Day 1971. For a fuller discussion see Höhler *Spaceship Earth*.

elaboration of what Killingsworth and Palmer call "millennial ecology."[42] The "speculative" and "emotional" qualities of Carson's text, along with its formal innovation as a thought experiment about the slow end of the world through pollution, led it to be dismissed by scientists in its own time as mere science fiction – trivial and fantastical.[43] But those qualities are now celebrated as the source of its "moral complexity" and rhetorical power.[44] Killingsworth and Palmer read *Silent Spring* as a creative experiment at the edges of popular science and science fiction, borrowing and rewriting apocalyptic tropes[45] to insist on the possibility of change and renewal.[46] In its wake, announcements and elaborations of environmental crisis proliferated in popular culture, co-mingling ideas and approaches from academic ecology, systems science, popular science and science fiction. Predictions of a ticking population bomb juxtaposed ideas about earth's carrying capacity drawn from ecosystems ecology with social and political scenarios of war, famine and sterilisation and suicide programmes.

In the 1960s and 1970s popular science often used futuristic narratives and science fictional rhetorics (sometimes carefully, sometimes indiscriminately[47]) to warn of impending environmental crisis. Paul Ehrlich, a prominent bioscientist, wrote narratives that mixed systems science, statistical demography and action-thriller storytelling to depict a world on the precipice of catastrophic overpopulation. His book *The Population Bomb* presented

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[42] Killingsworth and Palmer, "Millennial Ecology;" Killingsworth and Palmer, "*Silent Spring* and Science Fiction," 191.

[43] Killingsworth and Palmer, "*Silent Spring* and Science Fiction," 175.

[44] Killingsworth and Palmer, "*Silent Spring* and Science Fiction," 181.

[45] Killingsworth and Palmer, "Millennial Ecology."

[46] Killingsworth and Palmer, "*Silent Spring* and Science Fiction," 177.

[47] Killingsworth and Palmer ("Millennial Ecology," 32) describe Ehrlich's tone in *The Population Bomb* as that of "a prophet living in the last days." It is difficult now, however, not to read the opening of the book as an account of privileged white revulsion in response to an unfamiliar and densely populated city in the global South as much as a scientific treatise on global population.

dramatic fictional projections as popular science (although a related essay, 'Ecocatastrophe!' was later published in a science fiction anthology).[48] At the same time as popular science were projecting fantastical futures, science fiction writers and editors soberly claimed that their stories were about observable facts in the present, "not catastrophes of the imagination."[49] Near future dystopian narratives of systemic environmental collapse proliferated in in the 1960s (Harry Harrison's 1966 *Make Room! Make Room*, filmed as *Soylent Green* in 1973; John Brunner's 1968 *Stand on Zanzibar* and *The Sheep Look Up* 1972; Philip K Dick's 1968 *Do Androids Dream of Electric Sheep*). In the decade between *Silent Spring* and *The Limits to Growth*, the idea of a future environmental crisis emerged in multiple forms across popular science, genre fiction and environmental politics.

There was a powerfully utopian dimension to all these constructions of environmental crisis. It is often argued that ideas about limits framed the cultural mood of the 1970s in one-dimensionally "catastrophic"[50] or "pessimistic"[51] terms. McCray dwells on the "bleak assessment of the future"[52] launched by limits to growth, a sudden reversal of decades of progressive optimism, apprehensive about technology, anxious about pollution and resource depletion, looking ahead to a cramped, regressive future. Here the very idea of limits becomes a "shibboleth" for technological progressives who would go on to innovate a future defined against it in the name of technological expansion and enhancement.[53] Ross reads post-war futurology as the replacement of the future shock of nuclear annihilation by "dark eco-futures

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[48] Paul Ehrlich, *The Population Bomb* (New York: Ballantine Books, 1968); Paul Ehrlich, "Ecocatastrophe!" *Ramparts*, 1970.
[49] Disch, *Ruins*, pp. 16, 11. Another key anthology from this time was (eds.) Virginia Kidd and Roger Elwood *Saving Worlds* (New York: Doubleday, 1973), tagged a "collection of astonishing science fiction about the ecological *crisis*" [my emphasis].
[50] McCray, *The Visioneers*, 22.
[51] Ross, *Strange Weather*, 185.
[52] McCray, *The Visioneers*, 5.
[53] McCray, *The Visioneers*, 6.

predicated upon slow environmental deterioration and collapse."[54] The science fiction

dystopias of the period looked ahead to crowded cities, survivalist brutality and relentless

scarcity. The concerns and the aesthetics of these futures became less urgent but more

entrenched through the 1980s, not least in cyberpunk's rainy, crowded, decrepit cities, its dirty

realism and dreams of transcending the limits of the human body.[55]

But accounts of the period that dwell only on imagined futures of collapse, pessimism and

dystopia miss the element of warning and critique in dystopian science fiction, and the utopian

speculation that was also part of the idea of environmental crisis. A stark binary between

projected catastrophe and desired transformation was a hallmark of Western environmental

concern from the early 1970s to around 1990, when sustainable development became the more

powerful policy narrative framing environmental futures.[56] This mood of radical green hope is

often overlooked in histories of scientific ideas but is it vividly present in environmental

histories and in ecopolitical philosophy's accounts of its origins. Visions of better futures for

humans with nature are at the heart of deep ecology, which envisages an ecocentric

epistemology and ethics rooted in a recognition of the intrinsic value of nature and new modes

of human well-being linked to material sufficiency and connections with nature. The idea of

limits enables an alternative vision of living in place, of a rich culture of self-expression,

freedom from consumerism, consumption and alienation. Economic sufficiency would restore

humans to nature and to "the deep pleasure and satisfaction we [might] receive from close

partnerships with other forms of life."[57] Utopian speculation is also present in ecocentric

political proposals in the 1970s and 1980s with detailed descriptions of the no-growth

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[54] Ross, *Strange Weather*, 171.
[55] Ross, *Strange Weather*; see also Buell *From Apocalypse to Way of Life*.
[56] Douglas Torgerson, "Reflexivity and Developmental Constructs: The Case of Sustainable Futures."
Journal of Environmental Policy and Planning: 1-15. 10.1080/1523908X.2013.817949; Garforth, *Green Utopias*, 40-49.
[57] Arne Naess, "The Shallow and the Deep, Long-Range Ecology Movement," *Inquiry* 16: 96.

economy, appropriate technologies, bioregional decentralization, local democracy and a culture of communality and cooperation. In this period environmental thought embodies the aspect of apocalyptics that is about renewal and change, not despite but *because* it is also about the sense of an ending.[58]

Speculation about a better future within limits was powerfully expressed in literary science fiction from the middle of the 1970s to the early 1990s. Le Guin's *Always Coming Home*, Robinson's *Pacific Edge* and Marge Piercy's *Woman on the Edge of Time*[59] reinvented the genre of utopian fiction to respond to environmental crisis, articulate new political subjectivities, and bring to life alternatives to capitalist expansion.[60] These novels do not show environmental crisis directly, but it haunts their fictional futures. Piercy and Robinson set their utopian worlds one to two hundred years in the future and describe people and lifestyles embodying and enacting values of sustainability, small-is-beautiful, bioregional awareness and local democracy. But at the limit of their worlds the environmental crisis intrudes. In *Woman on the Edge of Time* characters fight a war at the temporal and spatial edges of the utopian future to ensure that their timeline will prevail. The novel's central present-day character, Connie Ramos, at one point crashes into the wrong future where environmental crisis has exploded in a hyper-capitalist future patriarchy. In *Pacific Edge*, we go back to the 1980s with the grandfather of the protagonist who is watching overshoot and collapse begin to unfold and

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[58] Killingsworth and Palmer,*"Silent Spring and Science Fiction;"* Stefan Skrimshire, "Eternal Return of the Apocalypse," in *Future Ethics: Climate Change and Apocalyptic Imagination* (London: Bloomsbury, 2010).

[59] Marge Piercy, *Woman on the Edge of Time* (London: The Women's Press, 1979 [1976]); Kim Stanley Robinson, *Pacific Edge* (London: HarperCollins, 1995 [1990]); Ursula K. Le Guin, *Always Coming Home* (London: Gollancz, 1986). These are not the only ecotopian fictions or utopian fictions with ecocentric elements published in this period (although they are probably the most clearly focused on sustainable futures as well as being narratively successful). Other examples include Ernest Callenbach's widely read *Ecotopia,* first published in 1974; Sally Miller Gearhart, *The Wanderground*, 1979; Joanna Russ *The Female Man*, 1975*;* Ursula K Le Guin *The Dispossessed*, published in 1974.

[60] Tom Moylan, *Demand the Impossible: Science Fiction and the Utopian* Imagination (Berlin: Peter Lang, 2014 [1986]).

searching for the utopian desire and political strategies to change it. In *Always Coming Home* Le Guin presents a radically ecocentric future documented through the texts of an imagined anthropology, a society that seems to exist because it has severed all narrative and historical connection to our own time. The people of the Valley, it is said, "have always lived there."[61] But still crisis persists into the Valley: the material detritus of a long, slow apocalypse; the stories people tell of stumbling into a world where "the air is thick and yellow" and "the road is coated with grease and feathers."[62]

The binary between utopian and dystopian futures both within science fiction texts and across the genre was part of a wider cultural response to ecological concerns from the 1970s onward. There was one path going ahead to the future, and it could go in one of two sharply divided directions: continuity vs change, rational intervention vs catastrophe, a better future with nature versus business as usual. This dualism, I argue, is a product of the projection of possible environmental crisis at a global scale into a far-away future. The idea of environmental crisis in the early 1970s was dependent upon certain kinds of scientific modelling. But the science fictionality that is also part of environmental crisis is not simply a reflection on those scientific projections. The very ideas that made up environmental crisis are science fictional, and its elaboration in (popular) science and science fiction are in many ways chronologically and formally inseparable. Insofar as the science fictional imagination was a critical part of environmental crisis and environmental knowledges in the 1970s to the 1990s, so was a rich sense of the social, also predominantly conceived in terms of a clear contrast between business as usual and the possibility of radical change, This would change significantly as ideas of environmental futures have become more and more dominated by climate modelling.

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[61] Le Guin, *Always Coming Home,* 99.
[62] Le Guin, *Always Coming Home,* 155-6.

Unmodelling apocalypse: climate science and science fiction in the early 21ˢᵗ century

The scientific basis of future climate scenarios is more robust and secure than previous forms of environmental modelling. But the social and even utopian elements that were so important in the first iteration of environmentalism's futures are less radical and more fugitive. I want to argue that this is because the kinds of knowledges involved in projecting climate futures have changed, in concert with a shifting political and cultural context. Climate science and its institutions have helped to construct more plausible and detailed knowledge claims about possible and probable environmental futures. But some have argued that this consensus has been achieved at least in part by creating a gradualist map of climate change which does not formally acknowledge potentially catastrophic scenarios. The prospect of crisis has been effaced in climate policies, even as it has arguably been normalised in contemporary culture.[63] The future scenarios of contemporary climate science and policy are multiple and overlapping, not binary as in the limits trajectory. It is increasingly difficult to represent the future as radically discontinuous with the present, and harder still to imagine desirable possibilities in the context of locked-in carbon logics. In science fiction, however, enabled by a popular culture replete with tropes of climate crisis, the political, social and human dimensions supposedly evacuated from science and policy are vividly present. Science fiction continues to work with apocalyptic narratives to figure the ethical, metaphysical and even utopian possibilities of a climate changed world.

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[63] Buell *From Apocalypse to Way of Life*; Erik Swyngedouw, "Apocalypse Forever? Post-Political Populism and the Spectre of Climate Change," *Theory, Culture and Society* 27, nos. 2-3 (2010).

Modelling global climate systems and projecting climate futures has a complex history. Particularly important have been the emergence of GCMs (general or global circulation models) over the course of the twentieth century,[64] and the more recent adoption by the Intergovernmental Panel on Climate Change (IPCC) of standardized scenarios for developing policy responses to the climate problematic. By the 1930s, Edwards shows, GCMs had become the ideal for long-term climate modelling, launching attempts to draw on weather data to map how the atmosphere and oceans maintain thermal equilibrium by receiving and re-radiating solar energy.[65] By the 1970s, research programmes for developing GCMs were established at many US and other Western institutions.[66] They were designed and refined to show average climate patterns over long periods, to "display predictable symmetry, stability and/or periodicity"[67] and to filter out local specificity and short-term and anomalous weather events. By the early 1990s, under the aegis of the IPCC, a scientific consensus had emerged, based on converging GCM modelling: anthropogenic climate change was real, and it required global policy attention.[68] GCMs do not make forecasts based on specific data inputs. They "replicat[e] the world in a machine,"[69] using massive computer power to "simulate their own climates."[70] Climate dynamics drawn from historical data are spun up, stabilised (reach equilibrium)[71] and used to project possible future atmospheric trajectories under various conditions of climate forcings, the elements external to the system that drive large-scale changes.

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[64] Edwards, *A Vast Machine*.

[65] Edwards, *A Vast Machine*, 143.

[66] Edwards, *A Vast Machine*, 167.

[67] Edwards, *A Vast Machine*, 141.

[68] Edwards, *A Vast Machine*, 396-8.

[69] Edwards, *A Vast Machine*, 138.

[70] Edwards, *A Vast Machine*, 337.

[71] Edwards, *A Vast Machine*, 149.

Like Forrester's dynamic systems simulations, climate models are not about predictions. They are designed to foreground relationships and "the planet as a dynamic system: intricately interconnected, articulated, evolving, but ultimately fragile and vulnerable."[72] Climate models too have depended on the retrospective mobilization and aggregation of patchy and often incommensurable data.[73] Like the World Systems models, climate simulations are generally set to run over 50-100 years. New epistemological insights about climate depend on very high levels of abstraction, both spatial and temporal. In this loose political and conceptual sense, climate modelling did build on aspects of the world systems dynamics. But in its institutional and epistemic development, contemporary climate science rejected Forrester's methods.[74] It emerged from a very different network of tightly interlinked research centres and communities that are now stable and long-standing, and which have little connection with the earlier phase of environmental crisis modelling. Climate modelling is more sophisticated than the early days of global systems models, and climate knowledge is more tightly integrated.[75] Through the IPCC there has been a hybridisation of science and public policy knowledges[76] and the emergence of a distinct scientific and regulatory regime of climate governance.[77] At its centre are the models themselves, serving as "technical gateways"[78] in the stabilisation of climate knowledge, showing how economic activities in the past have created accumulations of carbon

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[72] Edwards, *A Vast Machine*, 2; see also John Urry, *Climate Change and Society* (Oxford: Cambridge, 2011), 25.

[73] Edwards, *A Vast Machine*, 337.

[74] Edwards, *A Vast Machine*, 37.

[75] Edwards, *A Vast Machine;* Urry, *Climate Change and Society*.

[76] Mike Hulme, *Why We Disagree About Climate Change: Understanding Controversy, Inaction and Opportunity* (Cambridge: Cambridge University Press, 2009); Piero Morseletto, Frank Biermann and Philipp Pattberg, "Governing by targets: *reductio ad unum* and evolution of the two-degree climate target," *International Environmental Agreements* (2017) 17: 655–676.

[77] Angela Oels, "Rendering climate change governable: From biopower to advanced liberal government?" *Journal of Environmental Policy & Planning*, 2005, 7(3), 185-207.

[78] Edwards, *A Vast Machine*, 37.

gases in the atmosphere and suggesting the paths of rising concentrations of GHGs in the atmosphere linked to rising global temperatures over the coming decades.

Within these sophisticated and tightly integrated epistemic machineries there are of course endemic and even irreducible uncertainties associated with attempts to predict the future of "large, complex and chaotic systems", a future which includes the humans and social institutions whose decisions and actions might change predicted outcomes.[79] Many suggest that the process of managing and hybridising climate knowledge around shared models has necessitated a reduction of the complexities in climate knowledge and resulted in an unduly narrow consensus on predicted climate futures. This has been read variously as the unintended outcome of mobilizing policy and science around a simplified boundary object;[80] an unavoidable consequence of the discursive construction of climate change as a governable knowledge-object;[81] and a deliberate strategy to make climate challenges appear amenable to rational management.[82] In any case, the result has been the dominance of gradualist models of climate change in global scientific and public policy models. Urry argues that the "reductionism" that is the source of GCM models' projective power also pushes them to converge around an orthodoxy that excludes the possibility of non-linear and abrupt change.[83] Climate models tend to filter out the uncertainties of complex systems and regional variation, and thus underestimate the complexity of "multiple physical and social feedback mechanisms."[84] Wynne argues that climate models have tended to smooth out amplifying

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[79] Hulme, *Why We Disagree*, 82.
[80] Morseletto et al, "Governing By Targets."
[81] Oels, "Rendering Climate Change Governable."
[82] Michael T. Boykoff, Frame and Samuel Randalls, "Discursive Stability Meets Climate Instability: a Critical Exploration of the Concept of 'Climate Stabilization,'" *Global Environmental Change* 20, no. 1 (2010).
[83] Urry, *Climate Change and Society*, 29.
[84] Urry, *Climate Change and Society*, 164.

dimensions of positive feedback loops and underestimate uneven accelerations and instabilities.[85]

There is a policy and political dimension to the tendency of climate models to converge around linear and gradualist futures. Since the late 1980s climate models have been increasingly important to, and underwritten by, the IPCC, whose UN mission is to provide rigorous review and filtering of climate science for decision-makers. The UN's policies on climate in the 20th century have emerged from and reproduce what Buyoff et. al. call the "myth of climate stabilization"[86] in attempts to rationally manage a situation in which emissions have long lives and cumulative effects. Greenhouse gases (GHGs) remain in high concentrations in the atmosphere long after the activities that produced them (may or may not) have ceased. The recent history of intensifying carbon economies means that GHG accumulations must now get worse before they can get better. Climate policies, therefore, have tried to project forward a threshold for a safe limit to GHG accumulations in the future, and then "work back to what emissions scenarios will get the world to that concentration."[87] This is perhaps the ultimate in technocratic approaches. Anticipated futures via quantitative extrapolation are expected to act back on the present. Seeking to protect a threshold between safety and danger, the stabilization approach assumes that GHG accumulations can be managed in order to keep global temperature rises within a predictable range. At the high end of that range, clearly, climate

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[85] Wynne, "Strange Weather, Again."
[86] Boykoff et. al., "Discursive Stability," 58.
[87] Boykoff et. al., "Discursive Stability," 58. A parallel, albeit less critical, argument is made about the emergence and stabilization of the 2 degree centrigrade upper target for temperature rises in United Nations Framework Convention on Climate Change (UNFCCC) policy over the last 25 years or so in Piero Morseletto et. al., "Governing by targets." Morseletto et al suggest that temperature targets work as a "reduction ad unum," simplifying divergent issues and elements into a "synthetic" and singular number that "increase[s] the sense of governability" of climate change (Morseletto et. al., "Governing by Targets," 656, 657). The two degree centigrade target, they suggest, began as an effective boundary object in climate science and policy, but since 2010 has become a "disembedded" and from meaningful methods and processes for implementation and hence politically ineffective (Morseletto et. al., "Governing by Targets," 658).

emissions scenarios imply dramatic changes. But crisis itself – the prospect of a future fundamentally discontinuous with the present, of catastrophic or runaway climate change – is not part of the model. Indeed, the model is designed precisely to treat the future as linear and calculable, and hence leave crisis out.

If the dominant mode of climate modelling has brought more certainty and expert consensus to bear on environmental futures, it has at the same time depended on and tended to reproduce an expectation (what Hulme calls a "delusion" [88]) of rational control. Over the past quarter century, climate change has emerged as a governable object in part through the construction of graphic emissions scenarios used by the third and fourth IPCC Assessment Reports. In its *Special Report: Emissions Scenarios* in 2000,[89] the IPCC developed four broad storylines (the 'SRES' scenarios) mapping divergent futures characterised by somewhat different demographic, socio-economic, technological and environmental trajectories, each with an estimate linking them to levels of annual GHG emissions and rising GHG atmospheric concentrations. Based on the SRES scenarios, the IPCC's Third and Fourth reports modelled increasing global average surface temperatures in a range from 0.4 to 4.0 degrees Centigrade. The SRES scenarios show multiple futures, usually on one synthesised graph, seven or eight fuzzy lines each representing one hundred years or so. The lines all rise – some gently, some steeply. But the graph shows no break or turning point. Presenting multiple scenarios and possible development paths appears to offer a rational choice between scenarios. The future becomes a realm of technocratic risk calculation and intervention.[90]

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[88] Mike Hulme, "Governing and Adapting to Climate: a Response to Ian Bailey's Commentary on 'Geographical Work at the Boundaries of Climate Change,'" *Transactions of the Institute of British Geographers* 33, no. 3 (2008), 424.
[89] Intergovernmental Panel on Climate Change, *Special Report: Emissions Scenarios* (United Nations Environment Programme, 2000).
[90] Boykoff et. al., "Discursive Stability."

Climate crisis scenarios can seem more scientific and less science fictional than their earlier limits counterparts. Earlier apocalyptic framings of climate change have been effaced, and technical/neoliberal governance posited as the only solution.[91] The social, political and existential concerns that were such a rich part of the mix of the 1970s environmental crisis are contained or effaced.[92] But outside the narrow realm of IPCC-endorsed climate science and policy, catastrophe narratives have been proliferating, offering rich social and political explorations of a range of climate changed futures, including non-gradualist and catastrophic ones. Science fiction quickly generated climate stories, mainly dark and dystopian. A brief list of novels would include Octavia Butler's *Parable of the Sower* in 1993, Bruce Sterling's *Heavy Weather* in 1994 and John Barnes' *Mother of Storms* in the same year among the earliest; a cluster of well-known titles following what Mike Hulme has called a "turning point" in the cultural positioning of climate change as real and urgent in the mid-2000s: Cormac McCarthy's *The Road* in 2006, Margaret Atwood's Maddaddam trilogy, especially *Year of the Flood* published in 2009, Stephen Baxter's *Flood* in 2008; Paolo Bacigalupi's *The Windup Girl* in 2009; and widely read Young Adult climate dystopias including Saci Lloyd's *The Carbon Diaries 2015* published in 2009 and Julie Bertagna's *Exodus* in 2002. Dystopian and apocalyptic climate science fiction is now ubiquitous in popular culture.[93] Most critics position such narratives not as warnings, as in the earlier phase of crisis writing, but as pessimistic, fatalistic and even conservative.[94] And populist framings of future climate catastrophe can of course work to obscure or refuse the possibility of renewal and social change, becoming thin

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[91] Oels, "Rendering Climate Change Governable."
[92] Urry, Climate Change and Society.
[93] Perhaps even more so in film than in literature; but I focus primarily on novel-length science fiction in this piece.
[94] See for one example Hulme, *Why We Disagree*, a book which is enormously nuanced in its argument for the need for a less narrowly scientific and more richly social approach to global warming but which criticises a "myth of climate Apocalypse" based on a very thin sub-section of dystopian and post-apocalyptic science fiction and a weak engagement with the functions and forms of genre fiction. I discuss the social science and political theory rejection of apocalyptic narratives in relation to climate change more extensively in *Green Utopias*, 106-110.

"millennial" visions militating against collective historical interventions and suggesting a conservative desire to hold onto the same.[95]

But if there is nothing "inherently transformative" in apocalyptic narratives,[96] there is nothing inherently conservative about them either. In a contemporary context where climate management and hyper-rational framings of climate adaptation and mitigation dominate, visions of catastrophe stir up ideas that help us to resist and complicate mainstream gradualism, and keep social and political questions on the agenda.[97] In mainstream discourse there is, for Hulme, a "new climate reductionism … driven by the hegemony exercised by the predictive natural sciences over contingent, imaginative and humanistic accounts of social life and visions of the future."[98] Wynne suggests the need to develop a more "poetic" articulation of the climate dilemma, to enrich its sociological imagination, to expand "tacit imaginations of human and social actors and capacities" [99] against technocratic and gradualist discourses. For many commentators this work should be taken up in the social and human sciences and the newly-christened environmental humanities.[100] But this speculative technoscientific imagination, and especially the "poetics" of social critique, is precisely the work of science fiction.

Science fiction has brought its intense narrative focus on "the transformation of human societies as a result of the innovations attending technoscientific projects"[101] to bear on climate

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[95] Swyngedouw, "Apocalypse Forever?" 219. Frederick Buell, "A Short History of Environmental Apocalypse," in *Future Ethics: Climate Change and Apocalyptic Imagination*, edited by Stefan Skrimshire, 13-36 (London: Bloomsbury, 2010).

[96] Sarah Amsler, "Bringing Hope to 'Crisis': Crisis Thinking, Ethical Action and Social Change," in *Future Ethics: Climate Change and Apocalyptic Imagination*, edited by Stefan Skrimshire (London: Bloomsbury, 2010), 140.

[97] Skrimshire, "Eternal Return," 237.

[98] Hulme, "Reducing the Future to Climate," 245.

[99] Wynne, "Strange Weather, Again," 300. See also Hulme "Governing and Adapting to Climate Change."

[100] Eva Lövbrand, Silke Beck, Jason Chilvers, Tim Forsyth, Johan Hedren, Mike Hulme, Rolf Lidskog, Eleftheria Vasileiadou. "Who speaks for the future of Earth? How critical social science can extend the conversation on the Anthropocene," *Global Environmental Change* 32 (2015): 211-218.

[101] Csicsery-Ronay, *Seven Beauties*, 7.

science, and it has brought a wealth of genre resources to the exploration of possible, probable and desirable climate futures. As Trexler and Canavan argue, this work is not being done within the utopian forms characteristic of 1970s radical socio-political response to environmental crisis.[102] But it is not reducible to conservative catastrophism, and it includes powerful strands of utopian hope as well as clear-eyed critique. Contemporary Anthropocene fictions are reworking dystopian narratives and repurposing apocalypse to dwell in the parts of the climate projections that both science policy and sociology have avoided. Kim Stanley Robinson's Science in the Capital trilogy, for example, brings climate crisis and the case for a more radical and just science into everyday life and politics.[103] The novels are set five minutes ahead of the reader in an already mutating and multiplying present, blurring generic boundaries between speculation and realism.[104] In *Forty Signs of Rain*,[105] a chaotic weather event disrupts politics as usual when Washington D.C. floods. Domestic and urban spaces open up to strange new connections between humans and nonhuman subjects as individuals camp out with escaped zoo animals in former parks, and displaced people move in to extend the small nuclear Quibler family who are at the heart of the trilogy. Change in the name of sustainability comes not through the heroic individual actions but through the "bureaucratic" utopianism of networked collective agencies rippling through scientific and political institutions via "boring tasks" and everyday administration.[106]

Very recent Anthropocene science fiction has become even more explicitly utopian and activist. New climate genres like solarpunk self-consciously position themselves against the

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[102] Adam Trexler, *Anthropocene Fictions: The Novel in a Time of Climate Change*, (Charlottesville, VA: University of Virginia Press, 2015); Gerry Canavan, "Introduction," in *Green Planets: Ecology and Science Fiction* (Middletown CT, Wesleyan University Press, 2014).
[103] Trexler, *Anthropocene Fictions,* 159.
[104] Trexler, *Anthropocene Fictions*, 12-13.
[105] Kim Stanley Robinson, *Forty Signs of Rain* (Spectra, 2004).
[106] Trexler, *Anthropocene Fictions, 146,* 159.

closed and gradualist logics of climate policy and the apparent deadlock of environmental politics, but they also work creatively with mainstream catastrophism. They are keeping the future open to the social imagination, to think beyond both business as usual and "mere survival."[107] They explore "the struggles of humanity in an already apocalyptic or dystopian world."[108] Here real utopian possibilities exist not in contrast to dystopian extrapolation but in the midst of slowly and inexorably unfolding climate change and a range of iterations of its catastrophic consequences, often figured spatially. In Robinson's *New York 2140*,[109] partial urban flooding of New York creates new intertidal zones, both literally and metaphorically. There are new risks – flooded and collapsing buildings in Manhattan; the intensification of "shock doctrine" capitalism and precarious work across the globe. But there are also diverse communities inventing new and better social forms and ways of life together, making both material and political change from high-rise farms to financial market disruption. In Doctorow's *Walkaway*,[110] people are made unemployed by automation and permanently precarious by a new caste of the super or "zotta"[111] rich. They walk away to form improvised, shifting communes at the spatial and social edges of so-called default reality, where hollowed out cities meet a polluted countryside meet the open spaces of a super-advanced wireless cloud. In an only partly ironic spirit, they tell each other that they are enacting "the first days of a better world."[112] They mobilise a multitude of post-scarcity possibilities created by new

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[107] Phoebe Wagner and Brontë Christopher Wieland, "Editor's Note" in *Sunvault: Stories of Solarpunk and Eco-speculation*, edited by Phoebe Wagner and Bronte Christopher Wieland (Nashville, TN: Upper Rubber Boot, 2017), 9.

[108] Andrew Dincher "Foreword: On the Origins of Solarpunk," in *Sunvault: Stories of Solarpunk and Eco-speculation*, edited by Phoebe Wagner and Bronte Christopher Wieland (Nashville, TN: Upper Rubber Boot, 2017), 7.

[109] Kim Stanley Robinson, *New York 2140* (New York: Orbit, 2017).

[110] Cory Doctorow, *Walkaway* (New York: Tor, 2017).

[111] For a sense of the emergence of the idea of "zotta" in the world of the novel, see Doctorow *Walkaway*, 412.

[112] Doctorow, *Walkaway*, 62. The first instance of this idea, explained to three "noobs" to walkaway life by Limpopo, is couched in terms of a "better world." Subsequent occurrences are more usually phrased "the first days of a better nation," see *inter alia* page 377.

technologies of digital fabrication and negotiate the many interlocking and unfolding consequences of global warming. These include re-appropriating, as "spaces of hope,"[113] some of the ruined material and communal infrastructures left behind by a predatory late capitalism. This is the environmental crisis as "way of life" that Buell sombrely diagnosed in the early 2000s. But it is not the fiction of mourning and loss that Buell prescribed.[114] It is a fiction bursting with both the awfulness and the energy of the Anthropocene, with ideas for new hybrid natural-social alliances, with a speculative eye on the diverse possible social forms of liveable and perhaps in some respects better futures.

Back to the limits?

Scientific modelling has been part of modern environmentalism throughout the post-war period. In contemporary times the most prominent models are extremely sophisticated simulations of climate change trajectories. As Edwards argues, climate science now exhibits a high degree of consensus in relation to likely scenarios – not a single predictive "bright line," but a set of "shimmering," blurring, overlapping futures that offer a complex, multi-faceted and robust mapping of what might happen. They are not "predictive truth machines." But they are pretty good "reality-based social and policy heuristics."[115] By contrast, the systems dynamics models of the limits to growth were relatively simple, unintegrated, and data-poor.[116] I have argued, however, that it was precisely the somewhat crude temporal projection of a singular planetary crisis in *The Limits to Growth*, coupled with the blurry boundaries between popular science and science fiction, that helped 1970s environmentalism make its epistemological intervention into culture and consciousness. Crisis then made environmental

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[113] David Harvey, *Spaces of Hope* (Edinburgh: Edinburgh University Press, 2000).
[114] Buell, *From Apocalypse to Way of Life*.
[115] Wynne, "Strange Weather, Again," 295.
[116] Edwards, *A Vast Machine*, 371-2.

futures a matter for social, political and ethical debate, and it produced powerful dystopian and utopian fiction. Crisis now is perhaps more realistic and less futuristic; climate change models are more scientific than science fictional. Environmental crisis in the 1970s framed the present as a "threshold" period, full of urgency and the possibility of radical change.[117] Climate crisis in the early C21st is all too aware that thresholds for change may be already passing; that we will have to live with climate dynamics already in train; and remains committed to the rational and incremental management of the climate challenge.

In recent years there have been demands that contemporary social and political thought should go 'back' to the limits to growth (if not *The Limits to Growth*). Some such demands are made in the name of re-mobilizing arguments for the end of economic growth, given renewed urgency and relevance in the aftermath of a period of global financial crises. Some suggest that the Club of Rome presciently announced the beginning of a period of environmental limits that we are still living through; that "[t]here is unsettling evidence that society is still following the 'standard run' of the original study; in short that we can go back to the science of limits.[118] Others base arguments for a return to limits on something more like its science fictionality: the novelty and shock of the environmental crisis of the 1970s, its promise to "shatter "the self-satisfied and self-regarding assurance of Western industrialism"[119] and radically re-imagine the future.[120]

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[117] Höhler, *Spaceship Earth*, 11.
[118] Tim Jackson and Robin Webster, *Limits Revisited: A Review of the Limits to Growth Debate* (All Party Parliamentary Group on the Limits to Growth, 2016, http://limits2growth.org.uk/revisited), 3. Others who have either continued to measure the variables included in the original models or who have returned to re-examine Limits data: See *inter alia* Ugo Bardi *The Limits to Growth Revisited* (New York: Springer, 2011); Roberto Pasqualino, Aled W. Jones, Irene Monasterolo and Alexander Phillips, "Understanding Global Systems Today: A Calibration of the World3 Model between 1995 and 2012." *Sustainability* 7, no. 8 (2015): 9864-9889. Donella H. Meadows, Jorgen Randers and Dennis L. Meadows. *Limits to Growth: The 30 Year Update* (White River Junction, VT: Chelsea Green Publishing, 2004).
[119] Wynne, "Strange Weather, Again," 298.
[120] Urry, *Climate Change and Society*, 166.

I have tried to argue however that the conditions in which the limits to growth could announce a shattering crisis and in which cultural narratives could play out stark political alternatives are no longer in place. Limits and climate crises belong to two distinct periods of environmental politics and consciousness, the first characterised by a forceful and radical challenge to dominant ideologies of progress and economic growth, the second unfolding in the context of the internalisation and normalisation of that challenge and the new challenge of climate change.[121] Crisis can no longer perform the old anticipatory or utopian function, in particular as a way of thinking against dominant assumptions of unlimited economic growth or the association of economic development with progress, justice and human wellbeing. As we have seen in relation to contemporary climate science fiction, crisis now has to be figured in terms of multiple futures that often shrink into the present. The binary certainties of the limits to growth have ceded to the many emergent possibilities of climate scenarios. Utopian desire and social alternatives must be thought of as growing within not in opposition to unfolding environmental catastrophe.

What Andersson characterises as "the great future debate and the struggle for the world" in the 1960s and 1970s was between technocratic expertise and quantitative predictions on one side and humanist reflection and utopian desire on the other.[122] In relation to environmental futures, by the 1990s and 2000s that struggle had been complicated by everyday apocalypse, resistance, indifference and new kinds of uncertainty in relation to climate and environmental crisis. But

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[121] This internalisation and normalisation has been discussed under a number of signs: sustainable development, ecological modernization, the politics of unsustainability *inter alia*. See for example discussions in Torgerson, "Reflexivity and Developmental Contexts"; Urry *Climate Change and Society*; Buell *From Apocalypse to Way of Life*; Swyngedouw, "Apocalypse Forever?"; Ingulfur Blühdorn, "Sustaining the Unsustainable: Symbolic Politics and the Politics of Simulation," *Environmental Politics* 16, no. 2 (2007): 251-75.
[122] Andersson, "The Great Future Debate," 1411.

as I have indicated in relation to the emerging fictions of climate and the Anthropocene, science fictionality remains a critical part of how we can come to understand environmental futures and environmental challenges. If mainstream climate governance and politics have written crisis out of their projected futures, science fiction has continued to use and transform the trope of crisis in order to both anticipate and challenge likely eco-futures. Science fiction is already doing the work that social scientists suggest is the proper job of sociologists and science studies: talking about discontinuous futures; re-socialising climate science; arguing about what matters ethically and ontologically as we move into the Anthropocene; working in-between the speculative and the real.

Acknowledgements

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