

SCIENCE and STORIES

Offering Hope for the Climate

SASKIA BEUDEL

While the idea of the Anthropocene as a new geological epoch is still under formal review by the stratigraphic community, the concept has attracted widespread attention and debate across diverse scholarly fields. The startling idea that human influence on the environment “has now become so large and active that it rivals some of the great forces of Nature”¹ has prompted a “rapprochement” between disciplines. As Tom Griffiths puts it, through an escalating sense of global environmental crisis, “the sciences and humanities – so often separated in our training and thinking – are now turning towards one another with a grateful and urgent

sense of opportunity and collaboration.”² This new turn is fuelled in large part by acknowledgment that the gap continues to yawn large between what we know “needs to be done and what is actually being done” to avert crisis.³

As Sverker Sörlin points out, environmental problems were seen for much of the twentieth century as the prerogative of the natural sciences – as problems to be solved through the expertise of environmental scientists.⁴ They are now understood as complex cultural, social and “collective action problems”⁵ that require diverse forms of expertise, experience and knowledge. In this regard the Anthropocene is perceived as a “multidisciplinary mental framework” that links science and engineering to social and cultural theories and practices.⁶

Expressions of interest in enhanced collaboration between the sciences and humanities can be found at a range of scales and in varying contexts, including large global environmental change (GEC)⁷ research initiatives such as Future Earth. Announced in 2012, Future Earth builds upon three decades of work conducted by predecessor programs including the International Geosphere-Biosphere Programme (IGBP, est. 1987) and the World Cli-

Scholars in the humanities know that stories change the way people act, the way they use available knowledge. The stories we live by determine the future. So, in harnessing the power of narrative, in listening to, rediscovering and generating true stories, we change the world.

Tom Griffiths

mate Research Programme (WCRP, est. 1980).⁸ To date, involvement of the humanities in the GEC field has been slight. Future Earth's intentions to "integrate" the humanities along with natural and social sciences thus marks a significant departure in GEC research strategies.

Desire for enhanced collaboration can also be found in smaller scale interdisciplinary initiatives such as IHOPE* (est. 2003) and RESCUE (2009-2011) and in many aims of the environmental humanities. For example, the editorial welcome to the inaugural volume of the journal *Environmental Humanities* stated its intention to foster "novel interdisciplinary approaches to scholarship... drawing the humanities and the natural and social sciences into dialogue in new and exciting ways."⁹ Ursula Heise notes that the environmental humanities seek "to respond to the call for new institutional formations to correspond to innovative kinds of knowledge" and to be relevant to broader public debates around environmental issues.¹⁰ In the field of the creative arts, actual rather than proposed collaborations seem to have flourished more readily, with a number of collaborations between performance and/or visual artists and scientists based around environmental themes.

This article is undertaken in the spirit of this unprecedented desire for enhanced conversation and dialogue between fields. It asks a simple question: what kinds of narratives emerge through interviews with environmental scientists who have either played key roles in GEC programs and/or studied the impacts of climate change on local environments. And what might these narratives have to offer broader non-specialist or non-scientific audiences to

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I will center my essay around an interview with Pep Canadell, the Executive Director of the Global Carbon Project (GCP), a core project of Future Earth (that was formed to "assist the international science community to establish a common, mutually agreed knowledge base supporting policy debate and action to slow the rate of increase of greenhouse gases in the atmosphere.")¹¹ Before turning to this interview, however, I want to place this discussion in the context of Rachel Carson's work, and how her writing helped shift the perception of science's supposed mastery over nature.

* Visit IHOPE at: <http://ihopenet.org/about/>

A Changed World

In 1958 author Rachel Carson wrote a remarkable letter to Dorothy Freeman. Formed in response to the establishment of nuclear science, her letter describes both a major transformation in the relationship between humans and nature, and in Carson's thinking about that relationship:

I suppose my thinking began to be affected soon after atomic science was firmly established. Some of the thoughts that came were so unattractive to me that I rejected them completely, for the old ideas die hard, especially when they are emotionally as well as intellectually dear to me. It was pleasant to believe, for example, that much of Nature was forever beyond the tampering reach of man—he might level the forests and dam the streams, but the clouds and the rain and the wind [were beyond his reach].... I have now opened my eyes and my mind. I may not like what I see, but it does no good to ignore it, and it's worse than useless to go on repeating the old "eternal verities" that are no more eternal than the hills of the poets.¹²

In *Silent Spring* Carson used different words to convey this momentous shift in the relationship between "man and nature," stating that both radiation and synthetic chemicals had changed "the very nature of the world—the very nature of its life."¹³ She noted that in a deep history of interaction between living things and their surroundings only one species, humans, had "acquired significant power to alter the nature of [their] world"¹⁴ and then only in the speck of time represented by the twentieth century.

As well as describing revolutionary change in the nature of the world, Carson's letter describes transformative change in her own thinking. As can be inferred from the numerous calls for new forms of multidisciplinary collaboration mentioned earlier, responding to environmental crisis does not simply require better scientific understanding (more knowledge and data), it requires willingness to act, respond and change. Reasons for societies failing to take necessary decisions to halt global warming lie within social and cultural traditions and habits, within ideological, political, economic and other values, as well as in views on personal freedom.¹⁵

Numerous commentators have noted that anthropogenic environmental change requires new kinds of action at both individual/psychological and communal/sociological levels of behavior. Yet behavioral change that is fast and effective enough is precisely what is so elusive. Karen O'Brien and co-authors argue that to overcome resistance to transformative change requires "exploring one's own (individual and collective) assumptions, which often involves confronting existing priorities, interests, habits and loyalties that can be threatened by processes of change."¹⁶ Carson's letter points to her capacity to undertake just this kind of difficult self-reflexive work. She describes identifying and then relinquishing certain dearly-held beliefs, loyalties, and habits of mind in order to develop new ways of acting in and attending to the world.

Her apprehension at both intellectual and emotional levels of a "changed world" resulted in a significant shift in her practices as a writer. She undertook a transition from her earlier more lyrical books on the sea written in a nature-writing tradition, in which people scarcely appear, to the politi-

cized *Silent Spring*, for which she is best known today. In *Silent Spring* she systematically maps and challenges the indiscriminate and undemocratic use of “biocides” for economic gain, and she brings to life in pioneering ways the inseparability of human bodies from broader ecological systems (water, soil and atmosphere).

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Her role as “activist-writer”¹⁷ has granted her iconic status. In the popular imagination, *Silent Spring* launched the modern environmental movement. Her book is widely acknowledged for effecting tangible change in the real world. It led to the establishment of the Environmental Protection Agency in 1970 and prompted the passage of the Clean Air Act (1963), among others. Scientists recognize Carson as one of a handful of “precursors of our present concerns with Earth System integrity,” along with Aldo Leopold, Paul Ehrlich, Garrett Hardin and Donella Meadows.¹⁸

I would like to suggest that Carson’s letter prompts a question for our own times: how do today’s GEC and other environmental scientists express the fundamental shift in the interrelationship between humans and nature encapsulated by the Anthropocene?

Just as atomic science prompted the realization that “humans could destroy the livability of the planet—whether intentionally or otherwise,”¹⁹ the notion of the Anthropocene prompts the realization that the earth we live upon is not the passive background to human affairs and human history often assumed since the Enlightenment.²⁰ Instead, it is an active force that speaks back and is “moved by”²¹ a myriad human-directed interventions upon its systems. Human activity and Earth system activity are bound together in powerful feedback networks. Knowledge of this interactive and whole Earth system breaks down the nature/culture divide embedded within so many modern Western habits of thought and collapses “the age-old humanist distinction between natural history and human history.”²² Nature can no longer be conceived as removed from society.

How has this revolutionary shift in “the very nature of the world” (as Carson might put it) registered among scientists who are responsible for analyzing, comprehending and articulating anthropogenic environmental change? In asking this question, I mean registered at the more personal level conveyed by Carson rather than within formal scientific discourses of peer-reviewed findings and mission statements, which, of course, are already available in the public domain? What kinds of narratives do scientists form in response to this changed world we now all inhabit? Might these narratives provide broader audiences greater insight into, understanding of and imaginative apprehension of, our current situation?

Interview with Pep Canadell

I had the privilege of interviewing Pep Canadell in August 2017 in Canberra, Australia. We sat in a quiet ground floor meeting room at the Oceans and Atmosphere offices of the Commonwealth Scientific and Industrial Research Organisation (CSIRO) overlooking an empty green sport field. It seemed a long way from the hub of international scientific activities Canadell takes part in.

Canadell trained as a biologist in Spain during the 1980s and holds a Ph.D. in terrestrial ecology from the University Autonomous of Barcelona (1995). When he moved to the U.S. in the nineties he soon became drawn into the emerging field of Earth system and global change science. He became Executive Director of Global Change and Terrestrial Ecosystems (1998–2003), a core project of the International Geosphere-Biosphere Program, and has held the position of Executive Director of the Global Carbon Project since 2001. He has published over 140 scientific papers and books on topics stretching from terrestrial ecosystems and the impact of carbon earlier in his career to, more recently, the development of global and regional carbon budgets; processes driving carbon exchanges between the biosphere (the region of the earth occupied by living organisms) and atmosphere; and “assessment of CO² stabilisation pathways” for the future.²³ He also conducts public outreach and communication work, publishing regularly in forums such as *The Conversation*. As a member of the United Nations IPCC (Fourth

Assessment Report) he was awarded the Nobel Peace Prize in 2007. In 2017 he was elected a Fellow by the American Geophysical Union for outstanding contribution and discovery in Earth sciences and for contributing to scientific understanding needed to build a sustainable future.

Our interview ran for ninety minutes during which Canadell spoke generously and fluently throughout, expressing great enthusiasm and passion for his subject. Our conversation ranged across topics including developments in Earth system science from the 1990s onwards, and Canadell’s involvement in what he calls “informative advocacy.”²⁴ We discussed increasing *positive* responses to global warming including the uptake of renewable energy technologies in Texas, Europe and China; Canberra setting a 100% renewable energy target for 2020; the widespread availability of organic food in places like California, catering to mainstream rather than niche consumers (which breaks reliance on agricultural systems that use artificial nitrogen fertilizers while also making economic sense for businesses²⁵); the proposed phasing out of the combustion engine through government directives in the UK and France and through automotive industry decisions in Germany; and major banks refusing to loan money to the controversial Adani coal mine in Australia, a situation that would have been unthinkable a decade ago. Our conversation then turned to the question of meeting the Paris climate agreement to limit global warming to less than 2° Celsius above pre-industrial levels.

Tracking for the Future

How do you think we are performing in terms of a carbon budget²⁶ and emissions rates?

The first question is—what do we want to track? In Paris we agreed that we want to stay below 2° Celsius excess from pre-industrial rates. So we're doing very poorly, exceptionally so. This past week there was a new analysis as to how the rich world is tracking just for the targets for 2030, which are very modest, and even the rich countries are not playing their part,²⁷ let alone what you'd expect from places like China and India. For most of the community I work with, we don't think we can actually meet the Paris agreement. We think that it's going to go beyond 2° Celsius.

Two degrees is a social construct. There is no scientific basis by which, after 2° Celsius, the ice sheets are going to disintegrate and we're all going to be doomed under 20 meters of water and so on. It's a social construct in the sense that, given the science we know, the impacts we think are going to be there, and what we thought realistically could be done—and “realistic” is already a subjective thing—two degrees was first put on the table in the 90s, in the *mid-90s*. But we spent almost 25 years on international negotiations and diplomacy that took us absolutely nowhere. All the time, of course, we were elevating climate change as a very important issue. But the problem of waiting all this time is that our carbon budget shrank dramatically. So what in the mid-90s seemed, “well, we can do it,” later on became, “let's just try to do it.” The penalty for 25 years of non-action or little action is very big.

We know that we're going to overblow this carbon budget. That's what we're now talking about. When we signed the Paris agreement, we agreed that, in the second part of this century, we will have to develop technologies to remove carbon dioxide from the atmosphere. So if we go to zero carbon emissions by 2050,

which will be an incredible feat, an energy system that doesn't emit, and we get a good handle on some of the agriculture and the nitrogen, even then we won't reach the target agreement.

This first part of the century we'll overshoot the carbon budget, and then we need to go into the second half and start removing carbon dioxide from the atmosphere either with technologies that are not fully available or proven at this point, or are ridiculously expensive. What we discuss a lot is bioenergy. It's called biomass with carbon capture and storage.²⁸ The first plant was opened in the U.S. recently and captures a million tons of CO² per year. If we want to stay within the 2° Celsius target, we would need to do this big time. One million tons is nothing. We would need to have thousands and thousands of these plants all over the world if we were to go with this technology.

Beyond the Technological Fix

For the Paris agreement, we need to look at transformation that goes above and beyond technologies. If we were to deploy everything we have now on renewable energy, on carbon sequestration, it's still not enough. We have to look at the demand side, the social side of everything and rethink how we transport ourselves, what we eat.... All these end parts are very important. The way we work. Millions of people commuting hours and hours as though there's no tomorrow, how many miles you need to move just to work. With the internet and 3D printer, you can actually distribute the production of stuff in ways we never imagined. We always thought we had to have huge industrial plants that produce all this stuff. But people can now produce things in a smaller place at a more convenient location. Then we don't need to shift things from China 1,400 miles away. We talk a lot about this social transformation—it will be almost hand in hand with these super rapid technological transformations.

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In terms of assessing decarbonization pathways, we now have a section focused on consumer end powers. We're not saying we all have to become vegetarian, but a small reduction in meat consumption (say, a 1/3), and a small reduction in waste—if you put it

all together, you see all of a sudden you're going to achieve *as much saving here* as opposed to all these fancy technological expenses and studies.

That seems so important and also empowering. It means that more individuals need to take more responsibility. To me that's exciting because it's not the techno-fix, which is part of the system that got us to where we are in the first place, the capitalist paradigm.

It empowers people because they buy in to the problem, or into the solution, either way you want to look at it. So instead of saying, "Oh well, climate change, yet again the government is not really doing what it should be doing." Well no, because ultimately the government will do what we tell it to do. Let's be real. There's vested interest from big corporations, but ultimately even those big corporations are going to be fragile; they are already fragile, actually. The opportunities for individual buy-in are very strong because if you say, "Okay, if I'm going to reduce my meat consumption, I want my government, or my center, or my workplace, or whatever, to go and speak for climate change, because I'm doing my part and I expect you guys to be doing your part." It is empowering and can trickle through the whole system for the system transformation we need to undertake.

Window Into the Future

At this point, our conversation turned to the question of how soon Canadell expects the impacts of climate change to become more visible and acute.

Again, it's important that the 2° Celsius is not seen as this thing that, when you cross it, everything's terrible, and before you cross it, it's all good. It doesn't work like that. It's not a linear relationship of impacts. Climate change expresses itself in extremes. This cen-

tury we're going to have anywhere between half a meter and a little more of sea level rise. The issue is when you combine that massive, unusual once-in-a-century storm, with a king tide, with a 50 centimeter top-up of sea level. That's when you get events like flooding of the World Trade Center site when Hurricane Sandy hit New York. To me, this is an illustration. Of course Sandy was a very exceptional thing, but that's *exactly what we're talking about*.

You can get rid of all the coral reefs in Queensland and all the environmental fisheries in the mangroves of the Gulf of Carpentaria with a 1.5° Celsius increase. It happened with 1.2° Celsius in the last El Niño.

El Niños are an incredible window into the future because they bring all this heat and in a way put the world where it may be in thirty years' time, or twenty years' time. What happened in the last large El Niño of 2015-2016 is that we had all the issues with the coral reef bleaching,²⁹ and then about 700 kilometers of mangroves lining the Gulf of Carpentaria from Queensland all the way into the Northern Territory died *in a month*. This has never been reported anywhere else in the world.

There's been massive ecological transformation in this country and somehow these things don't go through the media enough because of... whatever. The mangroves were recorded by satellites, their leaves disappeared in a huge line. Mangroves are the spawning places of fisheries for local regions and also for export. This was the second big thing that happened. The third thing is that the Murray Darling River had one of its worst algal blooms. This is normal when waters get too hot; algae blooms and water cannot be used for irrigation or livestock, so it was a big deal even economically. The El Niño of 2015 was so big and hot that the algae that was part of that bloom was not one that belonged to the region. It came from hotter, adapted places up in Queensland. So we see all these things happening stronger and bigger than ever before to the point that even the biology behind these events has to be a different biol-

ogy because it's too hot for the old biology. The fourth thing that happened that summer, was fires in the alpine area of Tasmania. There are no records for the past 8,000 years (since the last glacial period) that there has ever been a fire in this part of the world. These are the *peats* that are permanently moist areas. It was so exceptionally dry. The fifth thing was high storm surges on the southeast coast. Although they can't be scientifically proven to be related to climate change, suffice it to say that every centimeter of sea level rise has a multiplier effect on the impact of storm surges. And finally there was the loss of 900 square kilometers of kelp forest along 100 kilometers of the Great Southern Reef in Western Australia. This occurred through a marine heatwave in 2011, but since its demise the kelp forest has shown no signs of recovery.³⁰

These ecological signs are *unprecedented*, all in this little window of a warmer world that El Niño brought for us. Globally, we were between 1.2° Celsius and 1.3° Celsius excess temperature at that point. We're saying we're likely to be beyond 2° Celsius. The potential impacts, as we move into a more permanent state of what El Niño brings us once every ten years or so—at some point these windows will be a true representation of how the world will be in years to come.

At this point in the interview I read Canadell the extract from Rachel Carson's letter. I asked him if he'd ever had a similar experience of deep-seated recognition that "the very nature of the world – the very nature of its life" had altered.

Not exactly like that, so probably not. But I'll tell you two things. One is actually everything I just told you, a full appreciation of what happened in the 2015-16 El Niño. It was so much in your face. And you just said that you didn't realize all these things happened, despite the communication efforts we made. When I go overseas and talk about it, people say, "How come we don't know about this stuff? It feels like the canary in the coalmine because

of the high sensitivity of Australia to climate change.” It’s among the most sensitive continents in this regard.

It was a *revelation* to me, because I could plot the impact of what’s still a fraction of the global warming we’re committing to. Getting this reaction from my overseas peers when I presented this stuff, I realized it is not a fiction we’re talking about.

We’re going to see this thing several times over, times many things, and the level of impact will be really important especially for more vulnerable communities, like the Pacific Islands and Bangladesh. We, all of us, have to have a say as to whether this thing is acceptable to us as a community as opposed to, this thing is going to come and there’s nothing we can do.

The second thing I just realized this morning: My fourteen-year-old son Jordi was telling me about a book he’s reading for school. It’s

a novel about this naïve little kid who goes through the Holocaust and finds explanations for why the regime, Hitler, was doing things to people, threatening them or even shooting them. There was always a “reasonable reason” that the little boy could come up with for why that thing happened. In the last third of the book, the kid realizes that he was just being naïve and that real stuff is happening. It made me think about climate change. We see things, a little signal here, a little signal there, but we say, “well, we’ve had this before, it’s a little worse, but you know....” Ten years passed, twenty years passed, twenty-five years passed since I started in the early nineties doing this work. At what point will we say, this is true and there’s nothing we can do, and we lost all this time.

I mean, it’s a terrible comparison and I’m not even sure we should be talking about this, but it feels a little like that.

Afterword

To conclude with my initial questions — what kinds of narratives do scientists form in response to the changed world we inhabit, and what might these narratives have to offer broader audiences — one observation is how *mixed* these narratives are. There are stories of hope and excitement: a sense that despite lack of clear directives at a federal government level, positive change is occurring across business, technological and grassroots community initiatives. As Canadell said with great enthusiasm during our interview, these positive transformations are now “unstoppable.”

In tandem with hopeful stories are narratives that bring audiences up close to the immediacy of climate change as it manifests in the present — through the demise of kelp forests, burning peats, bleaching coral, coastal storm surges,

migrating algae, and dying mangroves. As noted during the interview, some of these events were in the media, particularly the Great Barrier Reef and the fires in Tasmania, but few media reports connected the dots and read across multiple “signals” to glean the larger ecological picture Canadell captures in his metaphor of “windows into the future.” Glimpses through the window of the El Niño negotiate against more stereotypical images of future catastrophe (“under 20 meters of water and so on”) and apocalyptic narratives. They convey tangible and dispersed impacts of climate change in the here and now.

The vast scale of global warming, “massively distributed in time and space,” may be an impediment to more people taking action to curb climate change.³¹ Risks such as anthropogenic climate change, as Stuart Allan and his collaborators put it, “operate outside the capacity of (unaided) human

perception. This im/materiality gives [such] risks an air of unreality until the moment they materialise as symptoms.”³² Canadell’s observations help materialize otherwise amorphous phenomena of climate change. They bring climate change closer to home.

Glenn Albrecht’s work is a strong reminder that when environmental damage and change occurs in familiar and loved home-environments, not only does this result in psychological distress, it often results in action. Care and action feed one another. Although activism and action is not the focus of Albrecht’s research, it is clear in his account of developing his influential concept of “solastalgia” (“the homesickness you have when you are still at home”)³³ that residents of the Hunter Region in New South Wales, Australia, were not only distressed by their damaged environment; they were also taking action. As Albrecht notes, they were attempting to “halt the expansion of open cut coal mining and to control the impact of power station pollution.”³⁴ One potential contribution of narratives such as Canadell’s, whereby the “signals” of climate change that now surround us in all sorts of local

places are brought into relief, is that broader audiences and participants are able to engage with enriched “circuits” of information about climate change in order to make choices about actions.³⁵ Finally, Canadell’s narratives are a powerful reminder of individual and societal agency in the face of climate change. As artist Natalie Jeremijenko observed: “What the climate crisis has revealed to us is a secondary, more insidious and more pervasive crisis, which is the crisis of agency, which is what to do. Somehow buying a local lettuce, changing a light bulb, driving the speed limit, changing your tires regularly, doesn’t seem sufficient.”³⁶ While Jeremijenko vividly captures a common sense of inadequacy or uncertainty precipitated by climate change, Canadell’s statements about the relevance of “consumer end powers” or the “demand side” make clear that everyday choices at both individual and collective levels do indeed have measurable and significant impact. These actions and choices are not “insufficient” — they have the power, in Canadell’s words, to trickle through and transform the whole system. Change can start with each one of us.



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Notes

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2. Tom Griffiths, "The Humanities and an Environmentally Sustainable Australia," *Australian Humanities Review*, 43, (2007), accessed November 29, 2014, <http://australianhumanitiesreview.org/2007/03/01/the-humanities-and-an-environmentally-sustainable-australia/>.
3. Joern Fischer, et al., "Mind the Sustainability Gap," *Trends in Ecology and Evolution* 22, no. 12, (2007): 621–624, esp. 621.
4. Sverker Sörlin, "Reconfiguring Environmental Expertise," *Environmental Science & Policy* 28, (2013): 14–24.
5. Eva Lövbrand, et al., "Who Speaks for the Future of the Earth?" *Global Environmental Change* 32, (2015): 211–18, esp. 212.
6. *Welcome to the Anthropocene: The Earth is in Our Hands*, curated by Nina Möllers, Deutsche Museum, 2014–2016, <http://www.environmentandsociety.org/exhibitions/anthropocene/>.
7. According to the American Geophysical Union, "Global Environmental Change addresses large-scale chemical, biological, geological, and physical perturbations of the Earth's surface, ocean, land surface, and hydrological cycle with special attention to... human-caused perturbations, and their impacts on society."
8. Other programs include DIVERSITAS (est. 1991) and the International Human Dimensions Programme on Global Environmental Change (IHDP, established 1990).
9. Deborah Bird Rose, et al., "Thinking through the environment, unsettling the humanities," *Environmental Humanities* 1, (2012): 1-5, esp. 4-5.
10. Ursula K. Heise, "Comparative Literature and the Environmental Humanities," *State of the Discipline Report*, March 9, 2014, 10-18, esp. 9-10. <https://stateofthediscipline.acla.org/entry/comparative-literature-and-environmental-humanities>; See also, Christoph Kueffer, et al., "Developing the Environmental Humanities in Switzerland," *Swiss Academy of Humanities and Social Sciences* 23, no.1, (2015): 67-69.
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12. Rachel Carson, *Always Rachel: The Letters of Rachel Carson and Dorothy Freeman, 1952-1964*, Martha Freeman ed., Boston: Beacon Press, 1995, 248-49

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13. Rachel Carson, *Silent Spring* (London: Penguin Books, 2000), 23.
14. *ibid*
15. See Mike Hulme, *Why We Disagree About Climate Change* (Cambridge: Cambridge University Press, 2013); Naomi Klein, *This Changes Everything* (New York: Simon & Schuster, 2014); Anna Lowenhaupt Tsing, *A The Mushroom at the End of the World* (New Jersey: Princeton University Press, 2017).
16. Karen O'Brien, et al., "You Say You Want a Revolution? Transforming Education and Capacity Building in Response to Global Change," *Environmental Science & Policy* 28, (2013): 48-59, esp. 50.
17. Rob Nixon, *Slow Violence and the Environmentalism of the Poor* (Cambridge: Harvard University Press, 2011).
18. Frank Oldfield, et al., "The Anthropocene Review: Its Significance, Implications and the Rationale for a New Transdisciplinary Journal," *The Anthropocene Review* 1, no. 1, (2014): 3-7, esp. 4.
19. Tsing, *The Mushroom*, 3.
20. See, for example, Griffiths, "The Humanities and an Environmentally Sustainable Australia"; Dipesh Chakrabarty, "The Climate of History," *Critical Inquiry* 35, no. 2, (2009): 197-222.
21. Michael Serres, *The Natural Contract*, trans. Elizabeth MacArthur and William Paulson (Ann Arbor: University of Michigan Press, 1995), esp. 3-4. See also, Bruno Latour, "Is Geology the New Umbrella for all the Sciences? Hints for a Neo-Humboldtian University," (lecture, Cornell University, October 25, 2016), <http://bruno-latour.fr/sites/default/files/150-CORNELL-2016-.pdf>, esp.1.
22. Chakrabarty, "The Climate of History," 201.
23. Josep G. Canadell, "Carbon sciences for a new world," *Current Opinion in Environmental Sustainability* 2, (2010): 209.
24. Whereby scientific research aligns with pressing societal issues and policy needs to provide information useful to decision-making.
25. The amount of nitrogen used in farming is larger than natural nitrogen production. When nitrogen mixes with soil and atmosphere, it forms nitrous oxide, the third most problematic of the greenhouse gases after CO² and methane.

26. The Intergovernmental Panel on Climate Change (IPCC) recently identified the world's carbon budget as the "estimated amount of carbon dioxide the world can emit while still having a likely chance of limiting global temperature rise to 2° C above pre-industrial levels. The international scientific community estimates this budget to be 1 trillion tonnes of carbon (1000 PgC)... The world is currently on track to spend the remainder of this budget in just three decades."

27. Adrian E. Raftery et al., "Less than 2° C warming by 2100 unlikely," *Nature Climate Change* 7, (July 2017): 637-641, doi: 10.1038/NCLIMATE3352.

28. Biomass with carbon capture and storage (Bio-CCS) grows plants, which bind carbon from the atmosphere as they grow; puts them in combustion furnaces to produce electricity; captures the CO² produced and stores it underground; See Jasmin Kemper, "Biomass and Carbon Dioxide Capture and Storage: A Review," *International Journal of Greenhouse Gas Control* 40, (2015): 401-430.

29. Ocean temperatures in excess of 1° to 1.5° C above seasonal averages led to 90% of the top 1000^{km} of the Great Barrier Reef to suffer various degrees of bleaching with a 1/3 completely bleached; See also the recent documentary, *Chasing Coral*, <https://www.chasingcoral.com/> (accessed 23 May 2018).

30. Initially because of sustained above average ocean temperatures, and more recently because seaweeds have taken over the ecosystem.

31. Timothy Morton, *Hyperobjects: Philosophy and Ecology after the End of the World* (Minneapolis: University of Minnesota Press, 2013), 1.

32. Quoted in Hulme, *Why We Disagree*, 236.

33. Glenn Albrecht "'Solastalgia': A New Concept in Health and Identity," *PAN* 3, (2005): 41-55, esp. 41.

34. Albrecht, G "'The age of solastalgia'," *The Conversation*, 7 August 2012.

35. Hulme, *Why We Disagree*, 221-222.

36. Natalie Jeremijenko, "The Art of the Eco-Mindshift," (video of TED talk, October 2010), https://www.ted.com/speakers/natalie_jeremijenko.