

The Role of Life Scientists in the Biospheric Emergency: A Case for Acknowledging Failure and Changing Tactics

Fernando Racimo^{1,2,*}, Elia Valentini^{3,4,5}, Gaston Rijo De León^{6,7}, Teresa L. Santos^{8,9}, Anna Norberg^{10,11}, Lane M. Atmore^{12,13}, Myranda Murray^{10,11}, Sanja Hakala^{14,15}, Frederik Appel Olsen¹⁶, Charlie J. Gardner^{17,5}, Julia B. Halder^{18,5}

1. Globe Institute, Faculty of Health and Medical Sciences, University of Copenhagen, Denmark
 2. Scientist Rebellion Denmark
 3. University of Essex, Department of Psychology and Centre for Brain Science, Colchester, UK
 4. Scientist Rebellion Italy
 5. Scientist Rebellion UK
 6. Institut Pasteur, Université de Paris, CNRS UMR2000, Human Evolutionary Genetics Unit, F-75015 Paris, France
 7. Scientist Rebellion France
 8. cE3c Centre for Ecology, Evolution and Environmental Changes & CHANGE - Global Change and Sustainability Institute, Departamento de Biologia Animal, Faculdade de Ciências, Universidade de Lisboa, 1749-016 Lisboa, Portugal
 9. Scientist Rebellion Portugal
 10. Centre for Biodiversity Dynamics, Department of Biology, Norwegian University of Science and Technology, Trondheim, Norway
 11. Scientist Rebellion Norway
 12. Centre for Ecological and Evolutionary Synthesis, University of Oslo, Norway
 13. Scientist Rebellion Turtle Island
 14. Department of Biology, University of Fribourg, Switzerland
 15. Scientist Rebellion Switzerland
 16. Department of Communication, University of Copenhagen, Denmark
 17. Durrell Institute of Conservation and Ecology (DICE), University of Kent, UK
 18. School of Public Health, Imperial College London, UK
- * Corresponding author: fracimo@sund.ku.dk

Abstract

We are facing an emergency that encompasses the entire biosphere, with devastating consequences for both humans and the natural world on which we depend. As the climate and ecological crises accelerate, scientists are coming to terms with failings inherent in the modes of action we have used to engage society about their ongoing and future effects. Life scientists — including biologists, medical scientists, psychologists and public health experts — are no exception. Countless scientific articles, surveys, reports, and methodological advances have enabled exceedingly detailed assessments of the scale and rate of biological devastation, and its consequences for human health. Yet, we have failed to motivate governments and society as a whole to initiate the transformative change required to avoid further catastrophe. Here, we attempt to explain why our current modes of academic behaviour are undermining our own scientific recommendations, and emphasise the need to change the tactics we have used to effectively engage with society. We present a case for embracing activism in our scholarly responsibilities — including outreach, teaching and research — and to adapt these to the strategic logic of civil resistance. We then describe a number of past and present examples of scientist activism: a practice that is not new, but is in dire need of a radical revival.

Introduction

We are running out of time. Ecosystems across the planet are being destroyed at an accelerating rate. The life sciences — once a field dedicated to studying living systems and our interactions with them — are increasingly becoming sciences of the dead. Up to one million species are currently threatened with extinction, many of them within decades. This includes as many as 10% of insect species (IPBES 2019), as well as two in five plant species (Nic Lughadha et al. 2020). Many of the remaining species that are not immediately threatened by extinction are suffering population declines, affecting the functioning of all our ecosystems (Wagner 2020). Through a combination of unfettered land use change, exploitative farming practices, overfishing, and fossil fuel emissions, our planet is experiencing an extinction process of unprecedented speed (WWF 2020).

Current projections paint a grim picture for what our living planet will look like in the near future, as biodiversity loss is further compounded by climate breakdown (IPBES 2019). The UN Secretary-General, António Guterres, has recently stressed that “the evidence is irrefutable: greenhouse gas emissions from fossil fuel burning and deforestation are choking our planet” (UNO 2021). The latest Intergovernmental Panel on Climate Change (IPCC) report asserts we are en route to exceed 2°C global warming during this century (IPCC 2021). More recent estimates suggest that current policies are putting us on track to a median warming of 2.7°C by 2100 (with a 95% confidence range of between 2°C and 3.6°C; Climate Action Tracker 2022). This process will have devastating consequences on ecosystems worldwide, on which humans are intimately dependent. Research indicates that the human climate niche may dramatically shrink over the next 50 years, making large swaths of the planet incompatible with human survival and forcing mass displacements of hundreds of millions of people (Xu et al. 2020). It has been estimated that the disruption of our climate system will cause around 5 million excess deaths annually (Bressler 2021; Q. Zhao et al. 2021), via massively increased risks of heat stress, droughts, crop collapses, outbreaks of diseases and other natural disasters (World Health Organization 2021). The effect of these compound crises is exacerbated in lower-income countries, where the capacity for response is substantially decreased, due to centuries of colonial appropriation and resource depletion (Fanning et al. 2022; Hickel et al. 2022).

Life scientists are becoming highly effective at documenting the extermination of species and the destruction of ecosystems with excruciating detail - e.g. using the latest technologies in ecological surveying, computational modelling and conservation genomics - to keep a tally of the expanding death all around us (Hodgson et al. 2018; Cordier et al. 2021; Schmolke et al. 2010; Fitzpatrick and Keller 2015). Yet our measurements, predictions, and conclusions are overwhelmingly ignored by politicians, i.e. those with the most power to stop the global necrotic process. Even as researchers write countless warnings and reports on the biospheric emergency, it continues to worsen every year (Ripple et al. 2020; 2017; Pyšek et al. 2020; Georgian et al. 2022; Cavicchioli et al. 2019; Albert et al. 2021). The life sciences thus seem powerless to stop the destruction of their own subject of study.

What has gone wrong? In this article, we highlight how we — as life scientists — are failing in our duty to effectively engage with society about the biospheric emergency. We emphasise how a

focus on *status quo*-maintaining behaviours has cornered us into accepting practices and modes of communication that run counter to our own scientific recommendations. This, in turn, is hindering the transformative societal change needed to avert the worst consequences of the climate and ecological crises. Motivated by an academic environment that disincentivizes (and even sanctions) social and political critique, many natural scientists have resigned themselves to reporting on the consequences of the biospheric emergency, while shying away from its underlying social, economic and political causes.

We also provide ways in which we can break out of this dilemma, using effective forms of advocacy, via the growing scientist activism movement (Gardner and Wordley 2019; Capstick et al. 2022). We can — as scientists, without compromising our professional integrity — re-embrace engagement practices that lost steam over the past decades, yet were once integral to academic life.

Acknowledging failure

Life scientists study the natural world: its past, present and future, and its ongoing interplay with human society. In addition to producing knowledge, relaying that knowledge to the public is widely considered a scientific responsibility (Douglas 2009). Crucially, both the act of knowledge production and the act of dissemination exist to benefit our communities. Indeed, many scientists personally feel a sense of duty to increase and improve public understanding of research findings (Cerrato et al. 2018). This duty is also fundamental to many mission-driven professions within the life sciences: the role of conservation biologists and medical researchers, for example, includes an explicit obligation to create and disseminate knowledge in order to preserve life (Meine, Soulé, and Noss 2006; Romanello et al. 2021; Bennett et al. 2020).

Thus, for both personal and professional reasons, many life scientists have been trying to communicate the urgency of the climate and ecological crises for decades now, so as to trigger the cultural and political mechanisms able to prevent further ecosystem degradation and collapse (Diaz et al. 2019; Ripple et al. 2017). In their latest report, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) calls for “fundamental, system-wide reorganisation across technological, economic and social factors, including paradigms, goals and values” (IPBES 2019) whilst the IPCC urges “fundamental changes to how society functions, including changes to underlying values, worldviews, ideologies, social structures, political and economic systems, and power relationships” (IPCC 2022a).

Yet, our societies have not developed the radical, collective, co-ordinated systems change that a planetary-scale emergency would require. Given the level of urgency, it is critical to wonder how effective scientific efforts have been at producing transformative change, or even at generating substantial political capital to make change possible in the near future. We here highlight several key examples to illustrate the failure of life scientists to spark transformative change and galvanise political will: biodiversity loss and population decline, food security, and growing threats to global public health, including mental health. Each issue has garnered enormous attention from life scientists, yet continues to worsen every year.

Biodiversity and conservation

Nearly one out of every eight species is threatened with extermination, and many more have dramatically declining populations (IPBES 2019). This issue has touched virtually all research in ecology, as it is increasingly morphing into a science of extinction and risk assessment (Gardner and Bullock 2021). The biodiversity crisis garnered public attention in the mid-20th century with the publication of *Silent Spring* (Carson 1962). The following decades saw some success stories, such as the establishment of the US *Endangered Species Act* and the global ban on whaling, largely as a consequence of activism for these policies (Raymond 2018; Mackenzie 2018). Yet, these efforts are far from enough, and currently the preservation of biodiversity is at the bottom of the list of political concerns (Bradshaw et al. 2021).

The amount of funding dedicated to conservation reflects this stark reality; the spending on global protected areas is estimated to be approximately equal to the total money spent on beard-grooming products around the world (Gardner and Bullock 2021; Waldron et al. 2020; Thomas and Deshmukh 2019). Out of the 20 global targets agreed in 2010 as part of the Convention on Biological Diversity, zero were met by 2020 (Convention on Biological Diversity 2020). This is despite repeated calls from researchers for increased environmental protections and the creation of research and policy organisations such as the IPBES and the International Union for the Conservation of Nature. Research papers, media opinion pieces, and conference reports are clearly not creating the necessary impact for stopping or even slowing down species loss and population declines (Gardner et al. 2021; Green 2021).

Food security

The climate and ecological crises are deeply linked to threats to food security, as ecosystems on which humans are dependent are jointly disrupted by ecosystem decimation and climate breakdown (FAO 2019). Out of the world's agricultural land, 77% is used to support livestock, which is not only one of the largest sources of greenhouse gas emissions (Rojas-Downing et al. 2017; IATP, GRAIN, and Heinrich Böll Stiftung 2017) and global habitat destruction (Mundy 2021), but also makes up only 18% of the world's caloric supply, predominantly in high-income nations (FAO 2022). In addition, humans are now massively reliant on a select set of commodity crops, produced via industrial-scale monoculture farming and traded by a few corporations through international markets: maize, rice and wheat provide approximately 40% of humanity's chemical energy. They are predominantly grown in unevenly distributed continental grassland areas, which are particularly vulnerable to climate breakdown and consequent water scarcity (Dai 2013; Smaje 2020). Rising temperatures are directly reducing crop growth duration, effectively reducing yield (C. Zhao et al. 2017). Our crop production also relies on insect pollination, natural pest control and nutrient recycling by arthropods, all of which are threatened by the ongoing collapse of invertebrate populations (Wagner 2020). These issues have been exhaustively documented (Arora 2019; Hatfield and Prueger 2015; Gourdj, Sibley, and Lobell 2013) and have been the topic of discussion at large international organisations (FAO 2019).

After all this reporting and debate, are governments working to secure resilient food systems and decrease the risk of crop failures for the years ahead? The evidence points squarely against this.

The rate of fossil fuel emissions has never been higher, taking us rapidly away from the planetary safe zone in which our agricultural systems have existed for millennia (IPCC 2021; 2022a). A number of studies predict declines in global crop yields of between 20% and 90% within just a few decades, as a consequence of climate change, soil erosion and the decline in key pollinator populations (Schlenker and Roberts 2009; Arora 2019; Hatfield and Prueger 2015; Gourджи, Sibley, and Lobell 2013). Meanwhile, governments are neglecting to develop resilient and equitable food production and distribution strategies at the scale needed to prevent simultaneous crop collapses and famine (Tigchelaar et al. 2018; Gaupp et al. 2019). For example, a recent study showed that much of the research funded by the US Department of Agriculture is completely unrelated to sustainable agriculture, instead focusing on (unsustainable) animal farming or enhancing monoculture technologies: projects with a focus on agroecology and socioeconomic sustainability constitute just between 5% and 10% of allocated public funds (DeLonge, Miles, and Carlisle 2016).

Global public health

The biospheric emergency is linked to the deterioration of human health, through increasing exposure to extreme events (Romanello et al. 2021; Vicedo-Cabrera et al. 2021; Gasparrini et al. 2015), and our decreasing ability to effectively respond to epidemics (World Health Organization, 2021). As governments and corporations are demolishing the biosphere, they are forcing species to coexist in new ways, including new interactions between pathogens and potential hosts (Schmeller, Courchamp, and Killeen 2020; Carlson et al. 2022). More than half of human pathogenic diseases are predicted to be aggravated by climate change (Mora et al. 2022). Emerging epidemics in livestock and crops, as well as direct effects of climate on food production, will also increase the risk of malnutrition and famine (Romanello et al. 2021; Mora et al. 2022); undernutrition and disease will thus be overlapping threats to an increasingly vulnerable number of people worldwide.

In light of this knowledge, is the connection between ecosystems degradation and public health at the top of political and scientific agendas? Recent studies highlight our outstanding lack of preparedness for the coming plagues (Gibb et al. 2020; Romanello et al. 2021). As one of the co-authors of Gibb et al. commented, “We’ve been warning about this for decades. Nobody paid any attention” (Tollefson 2020). Multi-year medical research programmes are planned without mention of the context of rising temperatures and extreme weather, giving the incorrect impression that global health issues can be tackled regardless of the environmental conditions around us. Similarly, policymakers are neglecting to account for premature death related to heat stress from global temperature increases (Gasparrini et al. 2015), which has already claimed thousands of victims in 2022 (Coi and Weise 2022).

Mental health

A rapidly growing public health crisis concerns the effect of climate and ecological breakdown on mental health (Hayward and Ayeb-Karlsson 2021; Kelman et al. 2021; Royal College of Psychiatrists 2021). In the last IPCC Sixth Assessment Report (AR6), scientists overwhelmingly agreed that climate change has already had a negative global impact on mental health, and is

expected to worsen in the future (IPCC 2022a). A Web of Science search illustrates that research articles on the topic of “eco-anxiety,” “climate anxiety,” or “ecological grief” have skyrocketed from near-non-existence a couple of decades ago to hundreds of publications from 2020-2022 (Figure 1). Indeed, despite some taxonomic confusion (Clayton 2020), studies suggest a wealth of emotions associated with awareness of climate change (Brosch 2021). In the US alone, the burgeoning climate grief and anxiety crisis is seriously affecting the lives of about half of the adults aged 18 to 34 (APA 2020). Increases in heat exposure are also contributing to increased aggressivity and suicide rates (Miles-Novelo and Anderson 2019; R. Thompson et al. 2018).

Meanwhile, there is an ongoing shortfall in global mental health investment (WHO 2020), and calls to action have been made for professionals to urgently address these issues (Cunsolo and Ellis 2018; APA 2020). Even as numerous research studies are published on the topic, funding for mitigation and adaptation strategies in this area is still nowhere near the scale needed (Berrang-Ford et al. 2021; Hayes et al. 2018).

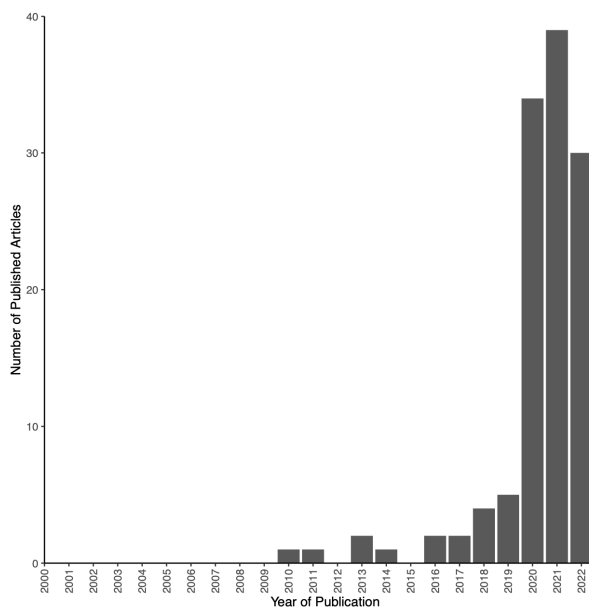


Figure 1. Web of Science results for research articles relating to climate and ecological anxiety. The Web of Science Core Collection was queried using the following search terms: TS=(climate NEAR/0 anxiety OR ecological NEAR/0 anxiety OR eco-anxiety OR ecological NEAR/0 grief). Articles pertaining to the issue of ecological anxiety have skyrocketed in the last 3 years. Note that, at the time of writing (12 August), 2022 is not over and already has nearly as many articles as 2021.

Life science education and dissemination

To top things off, universities around the world advertise degrees on the premise that a career in biological or ecological research will help protect endangered ecosystems, improve public health, or promote care for the environment. Yet, little is done to teach students about how their own specific disciplines will be affected by climate and ecological breakdown, and how this will, in turn, impact on their future career. More importantly, educational curricula rarely include training on scientific advocacy and communication strategies, or about the relationship between scientific behaviours and social change (Gardner et al. 2021; Green 2021; Leal Filho et al. 2021; Steinberger 2022). Instead, universities have largely emphasised approaching these crises via changes in individual behaviour rather than collective action and institutional accountability (Wynes and Nicholas 2017; Stevenson, Nicholls, and Whitehouse 2017; Robottom and Hart 1995) — an approach driven by the imposition of industrial and corporate control systems into

academia (Kleinman and Vallas 2001). University management narratives thus effectively shift the blame towards individuals, delay action, and leave the current generation of students with feelings of hopelessness and defeat, when in fact, systemic change is entirely within our grasp (Stoddard et al. 2021).

Overall, life scientists are failing at fully engaging society with the consequences of the biospheric emergency (Steinberger 2019). Whether we talk about threats to wildlife, food systems, or global health, the public either lacks an understanding of their fundamental causes (de Bruin et al. 2021), or is being actively misinformed (Lewandowsky 2020). The level of contamination of the public debate on the emergency has reached great sophistication, with entire think-tanks dedicated to occluding or misinterpreting scientific findings (Dunlap and Jacques 2013; Jacques, Dunlap, and Freeman 2008; Lamb et al. 2020; Lewandowsky 2021). Indeed, recent research highlights that correct information about climate and ecology is kept in memory for a short period of time and is often easily distorted by contrasting (wrong) information voiced by corporate-funded actors (Nyhan, Porter, and Wood 2022). Scientific counterweights to these misinformation campaigns have largely consisted in dry, dispassionate reporting to those in power (with the strongest interests in maintaining the *status quo*), rather than passionate and insistent communication with the people being misinformed: in short, a recipe for disaster (Steinberger 2019).

Changing tactics

It is clear that the current situation calls for a radical change to the way we engage with society. What would this involve? How can we become effective social actors in the biospheric emergency? Many scientists are now outlining a path forwards, which entails embracing advocacy and activism in academia (Gardner and Wordley 2019; Gardner et al. 2021; Capstick et al. 2022). Advocacy consists in taking a specific public stand in support of a cause – in this case, climate and ecological action – while activism refers to particularly direct forms of advocacy, like petitioning, protest or civil resistance. Among these, civil resistance has been shown to be highly effective at garnering public support, especially when done peacefully and en masse (Chenoweth, Stephan, and Stephan 2011). This involves publicly confronting or refusing to obey a particular law, order, power or rule deemed to be unjust or unethical, with the potential risk for detention or arrest. By placing oneself in a position of vulnerability with respect to a ruling regime (e.g. by blocking a road or occupying a building), one can generate public concern and sympathy, in ways other forms of engagement often fail to do (Thackeray et al. 2020). Indeed, civil resistance has been a major force behind societal changes over the past two centuries, including decolonisation processes, labour rights, women's voting rights, and civil rights for people of colour (Wright 2010; Chenoweth 2021).

Activism and advocacy need not be seen as a departure from our professional duties as academics, but rather as a natural adaptation of them to times of crisis (Gardner et al. 2021). Scientific freedom is indeed yoked together with responsibility (Douglas 2021). We are in a privileged position to be able to study life in its various forms, and produce knowledge about it — intimately attached to this freedom is the responsibility to use that knowledge to protect life. As stated in the handbook on research ethics published by the National Academy of Sciences: “[...] researchers also have the right to express their convictions and work for social change, and these

activities need not undercut a rigorous commitment to objectivity in research. The values on which science is based — including honesty, fairness, collegiality, and openness — serve as guides to action in everyday life as well as in research” (NAS, NAE and COSEMPUP 2009).

Not everyone agrees. It has been argued that scientists should not take normative stances on any subject, and should therefore limit themselves to informing politicians, policymakers and the public about the ever-worsening state of life on Earth (Wells 2018; Young 2017). Yet, this argument assumes that science can ever exist outside the political arenas that frame how science is practised in the first place. In fact, the vast majority of fields that are now regarded as essential to the scientific community initially grew out of conscious efforts to improve society and intervene in various crises. From genetic toxicology’s ties to the environmental movements of the 1960s and 70s (Frickel 2004a) to “crisis disciplines” such as epidemiology and conservation biology — with their inherent normative aim of preserving the foundations supporting human and non-human life (Soulé 1985; Susser and Bresnahan 2001; Meine, Soulé, and Noss 2006; Cox 2007) — the struggle for social progress is often, if not always, intrinsically part of knowledge production (Choudry 2020).

Scientists are, after all, citizens before scientists. All citizens in a society have a moral obligation to advocate for what they justifiably recognize to be right or good (Nelson and Vucetich 2009). Thus, our role as citizens entails a responsibility to participate in the betterment of society to the best of our abilities. The fact that we are also scientists should not prevent us from being good citizens, or to abdicate our societal responsibilities. On the contrary, we enjoy the privileged position of having first-hand access to scientific knowledge, so our responsibility is even greater. Indeed, in a crisis situation, failure to advocate for particular positions can have devastating consequences, and even lead to preventable loss of life (Pietrucci and Ceccarelli 2019; Benessia and De Marchi 2017). Even though many of us are working with non-permanent, short-term contracts – and often lack the rights of full citizens in the societies we live in – advocacy and activism can be a way to more deeply connect with those societies, while participating in global struggles that also affect our homelands (Frickel 2004b).

Some scientists and researchers are, perhaps understandably, wary of damaging their credibility by getting involved in addressing societal crises through advocacy and activism. However, research indicates that this fear may be unfounded (Kotcher et al. 2017). In fact, the public expects scientists to be actively involved in critical issues and participate in policy advocacy, because of their scientific expertise (Cologna et al. 2021). Studies show that, specifically when it comes to ecological activism by scientists, our objectivity is not inherently compromised by the political aspects of the research and communication (Isopp 2015). In the health sciences, for example, activism has been recommended as "sitting on a spectrum of possible health professional advocacy actions" (Bennett et al. 2020).

In contrast, the fear of being perceived as alarmists has caused serious impediments to accurate and effective scientific reporting. For instance, this fear has led researchers to consistently underestimate the negative impacts of climate and ecological breakdown (Brysse et al. 2013). It has also led many to communicate in dispassionate ways, even when passionate and emotional engagement has been shown to be much more effective in generating environmental action

(Brosch 2021). In the words of Marcus & Oranski: "Although the conduct of science demands honesty and rigour, nowhere is it written that researchers must remain silent when governments or other powerful players either misuse science or suppress findings in the service of harmful policies" (Marcus and Oransky 2017).

Expanding academic practices

Which specific forms of advocacy and activism can life scientists embrace today? Below, we outline three realms of academic activities in which these expanded academic practices can play pivotal roles in facilitating societal change: outreach, teaching and research (Figure 2).

Outreach is an essential aspect of being an academic. In the biospheric emergency, outreach must go beyond those activities currently considered conventional. An emergency calls upon us to actively participate in movements openly engaging with it, via effective forms of direct actions that can garner mass media attention (Chenoweth, Stephan, and Stephan 2011; Chenoweth 2020). In this context, alternative forms of academic outreach may involve, for example, wall-postering of scientific papers on polluting organisations (Real Media 2020), scientist blockades of streets or bridges (T. Thompson 2021), occupations of corporate or government facilities (Chiarin 2022), and academic strikes (Ambjørseiet 2022), to name a few. Scientists are also in a unique position to amplify voices of civil resistance that are currently under-powered. For instance, activists blocking the construction of an oil pipeline may be more likely to gain the favour of the public if they are backed by biologists, ecologists or public health experts, explaining to journalists why new pipelines are conducive to a dangerously unlivable planet.

In the realm of teaching, we can adapt educational practices to the strategic logic of civil resistance, in order to jointly provide knowledge and engage with the public, both inside and outside institutions of higher education. For example, we can organise street teach-ins while blocking traffic (Nielsen and Thymark 2021), interrupt our own course curricula with talks about the biospheric emergency (Steinberger 2022), or occupy university classrooms (Volkstimme 2022), thereby putting pressure on institutions to seriously mobilise their resources. The emergency also calls for a radical transformation of academic curricula, to provide students not just with knowledge about the consequences of climate and ecological breakdown, but also with the social and political tools to address their causes (Steinberger 2022).

Our research can also be expanded beyond business-as-usual, i.e. generating data, models, papers and reports that are placed behind inaccessible paywalls and are largely targeted to other academics (Veríssimo et al. 2020). Instead of building research programs designed for a world that the scientific consensus shows will not exist (IPCC 2021), we can instead refocus and repurpose our research, to equip society with transformative tools for change (e.g. <https://facultyforafuture.org/>; <https://aronlab.org/climate-psychology-and-action-lab/>) or aid activist groups in their local needs for strategy-development, community-building, and evidence-collection (Gardner et al. 2021).

Along these lines, knowledge production practices in the biospheric emergency should involve local stakeholders in extended peer communities, across all stages of the process (Funtowicz

and Ravetz 1993). They should also serve to transition away from the unsustainable patterns of thinking in which we have been raised to operate (Stengers 2018), and aid in the development of regenerative cultures (Wahl 2016). Even scientists working on basic science questions with no immediate direct applications can implement regenerative modes of knowledge production, and help change academic cultures. Perhaps most critically, it is vital for life scientists to listen to, collaborate and co-produce with social scientists, humanities scholars and indigenous communities: our modes of knowledge-production must be in open and honest dialogue with other modes that have been excluded by the colonial and neo-colonial projects that are contributing to the climate and ecological crises (Salomon et al. 2018; Stein et al. 2021).

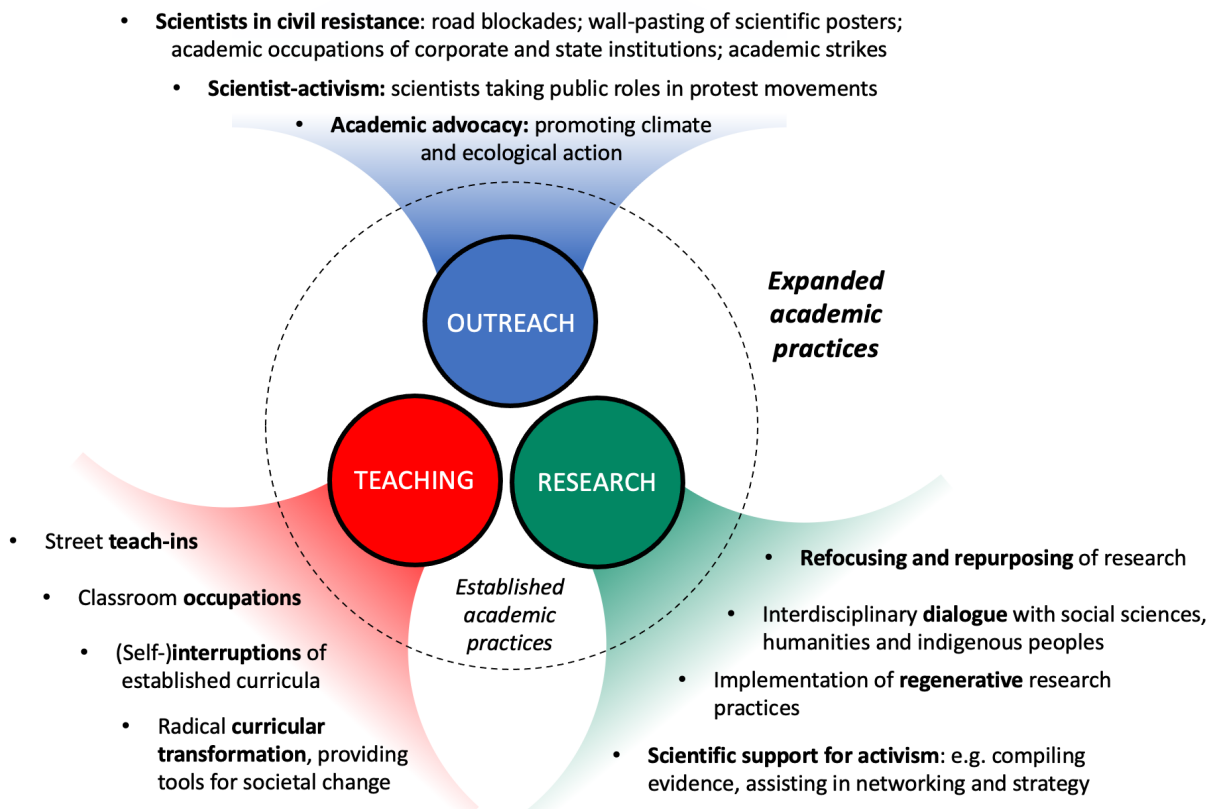


Figure 2. Examples of the new tactics for expanded academic practices which embrace activism and advocacy across different realms of academic activities: outreach, teaching and research.

Finally, across our research, teaching and outreach efforts, we must not shy away from naming the ultimate systemic drivers behind ecological breakdown, if we are to provide an honest assessment to society about the problems at hand. Statements that vaguely ascribe land degradation or species loss to “human activities” are often found in the life sciences academic literature, inviting gross mis-interpretations: not all humans are equally responsible, nor are all human activities destructive of nature. Indeed, the people and countries most affected by ecological breakdown and climate change are also the least responsible for them (Gore 2020; Oswald, Owen, and Steinberger 2020). Overly vague statements occlude the specific social, economic and political systems that are ultimately driving the biospheric emergency. These systems include, for example:

- **Extractivist capitalism**, which prioritises unfettered economic growth and environmental exploitation over long-term socio-ecological wellbeing (Jackson 2016; Hickel 2020; Schmelzer, Vetter, and Vansintjan 2022)
- **Settler-state colonialism**, which uses state-sanctioned violence to displace, imprison or murder indigenous land care-takers (Whyte 2018; Garnett et al. 2018; Stein et al. 2021; Global Witness 2018)
- **Corporate capture of state institutions**, which makes elected officials unwilling to act in favour of the interests of the broader public (Lucas 2021)
- **Disenfranchisement of citizens** from direct participation in decision-making processes (Smith 2009; Gerwin 2020), which perpetuates the incompetence of electoral politics in advancing transformative change (Gilens and Page 2014).

Ultimately, we must realise that scientific recommendations will be lost in the wind if they only take the form of polite appeals to dominant structures of power, particularly when those very same structures are the ones we are trying to transform. Instead, scientists stand to facilitate change more effectively by talking to the public about why these structures prevent us from fully tackling the emergency, and how they can be reshaped through popular struggle (Steinberger 2019; 2022).

Scientists in rebellion

Many scientists are already engaging in some of the aforementioned forms of activism, as the consequences of the climate and ecological crises become ever more present in our everyday lives (T. Thompson 2021). In April 2022, shortly after the publication of the sixth IPCC Working Group 3 report, the global Scientist Rebellion mobilised over 1,500 scientists across 28 countries, highlighting the dire global situation outlined by the report (IPCC 2022b). Researchers of all scientific backgrounds risked arrest across all continents, taking disruptive, non-violent actions directed at governmental, scientific and corporate institutions deemed responsible for the crises (C. Harvey 2022; Osborne 2022). The IPCC report itself had been leaked by anonymous scientists almost a year in advance — another form of scientist activism — due to fears it would be watered down by politicians and corporate lobbyists before publication (F. Harvey 2021). This fear was later shown to be founded, when the modified document was officially released to the public and contrasted to the leaked version (Bordera 2022).

Though regaining momentum today, scientist activism is not new (Figure 3). Its history is long, rich and diverse, testifying against the notion that it is unusual for researchers to get directly involved in societal problems (Moore 2009). Prominent scientists like Albert Einstein, Bertrand Russell and Linus Pauling actively engaged in the debate on the development of nuclear weapons and the dangers of modern warfare (Russell et al. 1955; Pauling 1958). American scholars and students participated in numerous teach-ins and strikes in the 1960s (Allen 2019), as did the Science for the People collective in the late 60s and early 70s, in order to protest the US-Vietnam War. Prominent biologists, like Stephen Jay Gould and Richard Lewontin, were key figures in this anti-war mobilisation (Schmalzer, Chard, and Botelho 2018). Likewise, activism has a proud tradition in the health sciences: scientist-campaigners like Florence Nightingale and Elizabeth

Garrett Anderson contributed to major gains in social welfare rights for underprivileged groups, and in the fight for women’s right to vote (Laurer 2021).

Throughout the 20th and 21st centuries, well-known scientists have participated in activism specifically targeted against ecological deterioration. As early as the 1920s, activist biologists in Brazil were instrumental in influencing public policy to advance environmental protection policies (Duarte 2016). More recently, the climatologist James Hansen has repeatedly engaged in activism, ever since his historical testimony to the US Senate in 1988 to raise public awareness about climate change and its effects on the biosphere. This has often been in the form of civil resistance, leading to arrest (Bryner 2013). Another example is the Argentine biologist Esteban Servat, who rose to global fame after publishing a secret government report on the disastrous effects of fracking in Mendoza, and was then forced into exile from his own country (Ketcham 2019). He has also been responsible for co-organizing mass mobilizations across the world, highlighting links between social struggles in impoverished nations with environmental abuses by European and North American corporations (Ketcham 2019; Monbiot 2022).



Figure 3. Timeline of a small subset of scientist activist examples from recent decades. None of the tactics outlined in this article are new, nor are their usage by academics, in light of the historical records of our field. Warming stripes credit: Ed Hawkins.

Moving forwards

We — the authors of this manuscript — are (mostly) life scientists¹, and hence our scope largely focuses on life science fields and practices. However, we believe our recommendations are broadly applicable to all scientists and academics, regardless of their area of expertise. In times of emergency, the entire scientific community must act their part: we are among the most trusted members of society (Funk et al. 2020) and we cannot let our immense prestige, knowledge and privilege go to waste.

We set out to write this perspective because we are all currently participating in activism. We ask our colleagues, mentors, students and teachers to join us. Let us not turn ourselves into passive witnesses of mass death and extinction. We are life scientists after all — let's stand up for life.

Acknowledgments

We thank Aaron Thierry, Renate Spooner, Graham Gower, Paula Zarén and Jacob Slusser for helpful comments, advice and support. We also want to thank the entire Scientist Rebellion movement for the inspiration to write this piece. For more information about scientist activism, visit www.scientistrebellion.com or contact any of the authors.

References

- Albert, James S., Georgia Destouni, Scott M. Duke-Sylvester, Anne E. Magurran, Thierry Oberdorff, Roberto E. Reis, Kirk O. Winemiller, and William J. Ripple. 2021. "Scientists' Warning to Humanity on the Freshwater Biodiversity Crisis." *Ambio* 50 (1): 85–94. <https://doi.org/10.1007/s13280-020-01318-8>.
- Allen, Jonathan. 2019. *March 4, Anniversary Edition: Scientists, Students, and Society*. MIT Press.
- Ambjørseiet, Tuva Martine. 2022. "Forskere og aktivister streiket for klima." April 6, 2022. <https://underdusken.no/klima-ntnu-streik/forskere-og-aktivister-streiket-for-klima/303204>.
- APA. 2020. "Majority of US Adults Believe Climate Change Is Most Important Issue Today." <https://www.apa.org/news/press/releases/2020/02/climate-change>.
- Arora, Naveen Kumar. 2019. "Impact of Climate Change on Agriculture Production and Its Sustainable Solutions." *Environmental Sustainability* 2 (2): 95–96. <https://doi.org/10.1007/s42398-019-00078-w>.
- Benessia, Alice, and Bruna De Marchi. 2017. "When the Earth Shakes ... and Science with It. The Management and Communication of Uncertainty in the L'Aquila Earthquake." *Futures, Post-Normal science in practice*, 91 (August): 35–45. <https://doi.org/10.1016/j.futures.2016.11.011>.

¹ All the authors of this manuscript are life scientists, with the exception of F.A.O., who is an expert in the rhetoric and history of scientist activism.

- Bennett, Hayley, Alexandra Macmillan, Rhys Jones, Alison Blaiklock, and John McMillan. 2020. "Should Health Professionals Participate in Civil Disobedience in Response to the Climate Change Health Emergency?" *The Lancet* 395 (10220): 304–8. [https://doi.org/10.1016/S0140-6736\(19\)32985-X](https://doi.org/10.1016/S0140-6736(19)32985-X).
- Berrang-Ford, Lea, Anne J. Sietsma, Max Callaghan, Jan C. Minx, Pauline F. D. Scheelbeek, Neal R. Haddaway, Andy Haines, and Alan D. Dangour. 2021. "Systematic Mapping of Global Research on Climate and Health: A Machine Learning Review." *The Lancet. Planetary Health* 5 (8): e514–25. [https://doi.org/10.1016/S2542-5196\(21\)00179-0](https://doi.org/10.1016/S2542-5196(21)00179-0).
- Bordera, Juan. 2022. "How the Corporate Interests and Political Elites Watered down the World's Most Important Climate Report." April 27, 2022. <https://mronline.org/2022/04/27/how-the-corporate-interests-and-political-elites-watered-down-the-worlds-most-important-climate-report/>.
- Bradshaw, Corey J. A., Paul R. Ehrlich, Andrew Beattie, Gerardo Ceballos, Eileen Crist, Joan Diamond, Rodolfo Dirzo, et al. 2021. "Underestimating the Challenges of Avoiding a Ghastly Future." *Frontiers in Conservation Science* 1. <https://www.frontiersin.org/articles/10.3389/fcosc.2020.615419>.
- Bressler, R. Daniel. 2021. "The Mortality Cost of Carbon." *Nature Communications* 12 (1): 4467. <https://doi.org/10.1038/s41467-021-24487-w>.
- Brosch, Tobias. 2021. "Affect and Emotions as Drivers of Climate Change Perception and Action: A Review." *Current Opinion in Behavioral Sciences*, Human Response to Climate Change: From Neurons to Collective Action, 42 (December): 15–21. <https://doi.org/10.1016/j.cobeha.2021.02.001>.
- Bruin, Wändi Bruine de, Lila Rabinovich, Kate Weber, Marianna Babboni, Monica Dean, and Lance Ignon. 2021. "Public Understanding of Climate Change Terminology." *Climatic Change*, 21.
- Bryner, Jeanna. 2013. "NASA Climate Scientist Arrested in Pipeline Protest." *Livescience.Com*. February 14, 2013. <https://www.livescience.com/27117-nasa-climate-scientist-arrest.html>.
- Bryse, Keynyn, Naomi Oreskes, Jessica O'Reilly, and Michael Oppenheimer. 2013. "Climate Change Prediction: Erring on the Side of Least Drama?" *Global Environmental Change* 23 (1): 327–37. <https://doi.org/10.1016/j.gloenvcha.2012.10.008>.
- Capstick, Stuart, Aaron Thierry, Emily Cox, Oscar Berglund, Steve Westlake, and Julia K. Steinberger. 2022. "Civil Disobedience by Scientists Helps Press for Urgent Climate Action." *Nature Climate Change*, August, 1–2. <https://doi.org/10.1038/s41558-022-01461-y>.
- Carlson, Colin J., Gregory F. Albery, Cory Merow, Christopher H. Trisos, Casey M. Zipfel, Evan A. Eskew, Kevin J. Olival, Noam Ross, and Shweta Bansal. 2022. "Climate Change Increases Cross-Species Viral Transmission Risk." *Nature* 607 (7919): 555–62. <https://doi.org/10.1038/s41586-022-04788-w>.
- Carson, Rachel. 1962. *Silent Spring*. Boston: Houghton Mifflin.
- Cavicchioli, Ricardo, William J. Ripple, Kenneth N. Timmis, Farooq Azam, Lars R. Bakken, Matthew Baylis, Michael J. Behrenfeld, et al. 2019. "Scientists' Warning to Humanity: Microorganisms and Climate Change." *Nature Reviews Microbiology* 17 (9): 569–86. <https://doi.org/10.1038/s41579-019-0222-5>.
- Cerrato, Simona, Valentina Daelli, Helena Pertot, and Olga Puccioni. 2018. "The Public-Engaged Scientists: Motivations, Enablers and Barriers." *Research for All* 2 (2): 313–22. <https://doi.org/10.18546/RFA.02.2.09>.
- Chenoweth, Erica. 2020. "The Future of Nonviolent Resistance." *Journal of Democracy* 31 (3): 69–84. <https://doi.org/10.1353/jod.2020.0046>.
- . 2021. *Civil Resistance: What Everyone Needs to Know*®. Oxford University Press.
- Chenoweth, Erica, Maria J Stephan, and Maria Stephan. 2011. *Why Civil Resistance Works:*

- The Strategic Logic of Nonviolent Conflict*. Columbia University Press.
- Chiarin, Mitia. 2022. "Clima, Ricercatori Si Incatenano Davanti Alla Raffineria Di Eni a Marghera." *La Nuova Di Venezia e Mestre*, 2022. <https://nuovavenezia.gelocal.it/venezia/cronaca/2022/04/06/news/clima-ricercatori-si-incatenano-davanti-alla-raffineria-di-eni-a-marghera-1.41354461>.
- Choudry, Aziz. 2020. "Reflections on Academia, Activism, and the Politics of Knowledge and Learning." *The International Journal of Human Rights* 24 (1): 28–45. <https://doi.org/10.1080/13642987.2019.1630382>.
- Clayton, Susan. 2020. "Climate Anxiety: Psychological Responses to Climate Change." *Journal of Anxiety Disorders* 74 (August): 102263. <https://doi.org/10.1016/j.janxdis.2020.102263>.
- Climate Action Tracker. 2022. "Despite Glasgow Climate Pact 2030 Climate Target Updates Have Stalled." <https://climateactiontracker.org/publications/despite-glasgow-climate-pact-2030-climate-target-updates-have-stalled/>.
- Coi, Giovanna, and Zia Weise. 2022. "Excess Deaths Surged as Heat Wave Hit Europe." *Politico*, March 8, 2022. <https://www.politico.eu/article/excess-death-surged-heat-wave-hit-europe/>.
- Cologna, Viktoria, Reto Knutti, Naomi Oreskes, and Michael Siegrist. 2021. "Majority of German Citizens, US Citizens and Climate Scientists Support Policy Advocacy by Climate Researchers and Expect Greater Political Engagement." *Environmental Research Letters* 16 (2): 024011. <https://doi.org/10.1088/1748-9326/abd4ac>.
- Convention on Biological Diversity. 2020. "Global Biodiversity Outlook 5." Montreal. <https://www.cbd.int/gbo5>.
- Cordier, Tristan, Laura Alonso-Sáez, Laure Apothéoz-Perret-Gentil, Eva Aylagas, David A. Bohan, Agnès Bouchez, Anthony Chariton, et al. 2021. "Ecosystems Monitoring Powered by Environmental Genomics: A Review of Current Strategies with an Implementation Roadmap." *Molecular Ecology* 30 (13): 2937–58. <https://doi.org/10.1111/mec.15472>.
- Cox, Robert. 2007. "Nature's 'Crisis Disciplines': Does Environmental Communication Have an Ethical Duty?" *Environmental Communication* 1 (1): 5–20. <https://doi.org/10.1080/17524030701333948>.
- Cunsolo, Ashlee, and Neville R. Ellis. 2018. "Ecological Grief as a Mental Health Response to Climate Change-Related Loss." *Nature Climate Change* 8 (4): 275–81. <https://doi.org/10.1038/s41558-018-0092-2>.
- Dai, Aiguo. 2013. "Increasing Drought under Global Warming in Observations and Models." *Nature Climate Change* 3 (1): 52–58. <https://doi.org/10.1038/nclimate1633>.
- DeLonge, Marcia S., Albie Miles, and Liz Carlisle. 2016. "Investing in the Transition to Sustainable Agriculture." *Environmental Science & Policy* 55 (January): 266–73. <https://doi.org/10.1016/j.envsci.2015.09.013>.
- Diaz, Sandra, Josef Settele, Eduardo Brondízio, Hien T. Ngo, John Agard, Almut Arneth, Patricia Balvanera, et al. 2019. "Pervasive Human-Driven Decline of Life on Earth Points to the Need for Transformative Change." *Science (New York, N.Y.)* 366 (December). <https://doi.org/10.1126/science.aax3100>.
- Douglas, Heather. 2009. *Science, Policy, and the Value-Free Ideal*. University of Pittsburgh Pre. ———. 2021. "Scientific Freedom and Social Responsibility." In *Science, Freedom and Democracy*, 68–87. New York, NY: Routledge.
- Duarte, Regina Horta. 2016. *Activist Biology: The National Museum, Politics, and Nation Building in Brazil*. University of Arizona Press. <https://library.oapen.org/handle/20.500.12657/43864>.
- Dunlap, Riley E., and Peter J. Jacques. 2013. "Climate Change Denial Books and Conservative Think Tanks: Exploring the Connection." *American Behavioral Scientist* 57 (6): 699–731. <https://doi.org/10.1177/0002764213477096>.

- Fanning, Andrew L., Daniel W. O'Neill, Jason Hickel, and Nicolas Roux. 2022. "The Social Shortfall and Ecological Overshoot of Nations." *Nature Sustainability* 5 (1): 26–36. <https://doi.org/10.1038/s41893-021-00799-z>.
- FAO. 2019. "The State of the World's Biodiversity for Food and Agriculture." <https://www.fao.org/state-of-biodiversity-for-food-agriculture/en/>.
- . 2022. "FAOSTAT 2022." 2022. <https://www.fao.org/faostat/en/#data>.
- Fitzpatrick, Matthew C., and Stephen R. Keller. 2015. "Ecological Genomics Meets Community-Level Modelling of Biodiversity: Mapping the Genomic Landscape of Current and Future Environmental Adaptation." *Ecology Letters* 18 (1): 1–16. <https://doi.org/10.1111/ele.12376>.
- Frickel, Scott. 2004a. *Chemical Consequences: Environmental Mutagens, Scientist Activism, and the Rise of Genetic Toxicology*. New Brunswick, NJ, USA: Rutgers University Press.
- . 2004b. "Just Science? Organizing Scientist Activism in the US Environmental Justice Movement." *Science as Culture* 13 (4): 449–69. <https://doi.org/10.1080/0950543042000311814>.
- Funk, Cary, Alec Tyson, Brian Kennedy, and Courtney Johnson. 2020. "Scientists Are among the Most Trusted Groups in Society, Though Many Value Practical Experience over Expertise." *Pew Research Center Science & Society* (blog). September 29, 2020. <https://www.pewresearch.org/science/2020/09/29/scientists-are-among-the-most-trusted-groups-in-society-though-many-value-practical-experience-over-expertise/>.
- Funtowicz, Silvio O., and Jerome R. Ravetz. 1993. "Science for the Post-Normal Age." *Futures* 25 (7): 739–55. [https://doi.org/10.1016/0016-3287\(93\)90022-L](https://doi.org/10.1016/0016-3287(93)90022-L).
- Gardner, Charlie J., and James M. Bullock. 2021. "In the Climate Emergency, Conservation Must Become Survival Ecology." *Frontiers in Conservation Science* 2. <https://www.frontiersin.org/articles/10.3389/fcosc.2021.659912>.
- Gardner, Charlie J., Aaron Thierry, William Rowlandson, and Julia K. Steinberger. 2021. "From Publications to Public Actions: The Role of Universities in Facilitating Academic Advocacy and Activism in the Climate and Ecological Emergency." *Frontiers in Sustainability* 2. <https://www.frontiersin.org/article/10.3389/frsus.2021.679019>.
- Gardner, Charlie J., and Claire F. R. Wordley. 2019. "Scientists Must Act on Our Own Warnings to Humanity." *Nature Ecology & Evolution* 3 (9): 1271–72. <https://doi.org/10.1038/s41559-019-0979-y>.
- Garnett, Stephen T., Neil D. Burgess, Julia E. Fa, Álvaro Fernández-Llamazares, Zsolt Molnár, Cathy J. Robinson, James E. M. Watson, et al. 2018. "A Spatial Overview of the Global Importance of Indigenous Lands for Conservation." *Nature Sustainability* 1 (7): 369–74. <https://doi.org/10.1038/s41893-018-0100-6>.
- Gasparrini, Antonio, Yuming Guo, Masahiro Hashizume, Eric Lavigne, Antonella Zanobetti, Joel Schwartz, Aurelio Tobias, et al. 2015. "Mortality Risk Attributable to High and Low Ambient Temperature: A Multicountry Observational Study." *Lancet (London, England)* 386 (9991): 369–75. [https://doi.org/10.1016/S0140-6736\(14\)62114-0](https://doi.org/10.1016/S0140-6736(14)62114-0).
- Gaupp, Franziska, Jim Hall, Dann Mitchell, and Simon Dadson. 2019. "Increasing Risks of Multiple Breadbasket Failure under 1.5 and 2 °C Global Warming." *Agricultural Systems* 175 (October): 34–45. <https://doi.org/10.1016/j.agsy.2019.05.010>.
- Georgian, Samuel, Sarah Hameed, Lance Morgan, Diva J. Amon, U. Rashid Sumaila, David Johns, and William J. Ripple. 2022. "Scientists' Warning of an Imperiled Ocean." *Biological Conservation* 272 (August): 109595. <https://doi.org/10.1016/j.biocon.2022.109595>.
- Gerwin, Marcin. 2020. *Citizens' Assemblies: Guide to Democracy That Works*. Krakow, Poland: Open Plan Foundation. <https://citizensassemblies.org/download/>.
- Gibb, Rory, David W. Redding, Kai Qing Chin, Christl A. Donnelly, Tim M. Blackburn, Tim Newbold, and Kate E. Jones. 2020. "Zoonotic Host Diversity Increases in Human-

- Dominated Ecosystems.” *Nature* 584 (7821): 398–402. <https://doi.org/10.1038/s41586-020-2562-8>.
- Gilens, Martin, and Benjamin I. Page. 2014. “Testing Theories of American Politics: Elites, Interest Groups, and Average Citizens.” *Perspectives on Politics* 12 (3): 564–81. <https://doi.org/10.1017/S1537592714001595>.
- Global Witness. 2018. “At What Cost? Irresponsible Business and the Murder of Land and Environmental Defenders in 2017.” Global Witness. <https://apo.org.au/node/184396>.
- Gore, Tim. 2020. “Confronting Carbon Inequality: Putting Climate Justice at the Heart of the COVID-19 Recovery.”
- Gourdji, Sharon M., Adam M. Sibley, and David B. Lobell. 2013. “Global Crop Exposure to Critical High Temperatures in the Reproductive Period: Historical Trends and Future Projections.” *Environmental Research Letters* 8 (2): 024041. <https://doi.org/10.1088/1748-9326/8/2/024041>.
- Green, Alison J. K. 2021. “Challenging Conventions—A Perspective From Within and Without.” *Frontiers in Sustainability* 2. <https://www.frontiersin.org/articles/10.3389/frsus.2021.662038>.
- Harvey, Chelsea. 2022. “Scientists Risk Arrest to Demand Climate Action.” *Scientific American*, 2022. <https://www.scientificamerican.com/article/scientists-risk-arrest-to-demand-climate-action/>.
- Harvey, Fiona. 2021. “IPCC Steps up Warning on Climate Tipping Points in Leaked Draft Report.” *The Guardian*, June 23, 2021, sec. Environment. <https://www.theguardian.com/environment/2021/jun/23/climate-change-dangerous-thresholds-un-report>.
- Hatfield, Jerry L., and John H. Prueger. 2015. “Temperature Extremes: Effect on Plant Growth and Development.” *Weather and Climate Extremes*, USDA Research and Programs on Extreme Events, 10 (December): 4–10. <https://doi.org/10.1016/j.wace.2015.08.001>.
- Hayes, Katie, G. Blashki, J. Wiseman, S. Burke, and L. Reifels. 2018. “Climate Change and Mental Health: Risks, Impacts and Priority Actions.” *International Journal of Mental Health Systems* 12 (1): 28. <https://doi.org/10.1186/s13033-018-0210-6>.
- Hayward, Gemma, and Sonja Ayeb-Karlsson. 2021. “‘Seeing with Empty Eyes’: A Systems Approach to Understand Climate Change and Mental Health in Bangladesh.” *Climatic Change* 165 (29): 1–30.
- Hickel, Jason. 2020. *Less Is More: How Degrowth Will Save the World*. Random House.
- Hickel, Jason, Christian Dorninger, Hanspeter Wieland, and Intan Suwandi. 2022. “Imperialist Appropriation in the World Economy: Drain from the Global South through Unequal Exchange, 1990–2015.” *Global Environmental Change* 73 (March): 102467. <https://doi.org/10.1016/j.gloenvcha.2022.102467>.
- Hodgson, Jarrod C., Rowan Mott, Shane M. Baylis, Trung T. Pham, Simon Wotherspoon, Adam D. Kilpatrick, Ramesh Raja Segaran, Ian Reid, Aleks Terauds, and Lian Pin Koh. 2018. “Drones Count Wildlife More Accurately and Precisely than Humans.” *Methods in Ecology and Evolution* 9 (5): 1160–67. <https://doi.org/10.1111/2041-210X.12974>.
- IATP, GRAIN, and Heinrich Böll Stiftung. 2017. “Big Meat and Dairy’s Supersized Climate Footprint.” <https://www.iatp.org/supersized-climate-footprint>.
- IPBES. 2019. “Global Assessment Report on Biodiversity and Ecosystem Services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.” Bonn, Germany: IPBES secretariat. https://knowledge4policy.ec.europa.eu/publication/global-assessment-report-biodiversity-ecosystem-services-intergovernmental-science-0_en.
- IPCC. 2021. “Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.” In . Cambridge University Press. <https://www.ipcc.ch/report/ar6/wg1/>.

- . 2022a. “Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.” In . Cambridge University Press. <https://www.ipcc.ch/report/ar6/wg2/>.
- . 2022b. “Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.” In . Cambridge University Press. <https://doi.org/10.1017/9781009157926>.
- Isopp, Bernhard. 2015. “Scientists Who Become Activists: Are They Crossing a Line?” *Journal of Science Communication* 14 (June). <https://doi.org/10.22323/2.14020303>.
- Jackson, Tim. 2016. *Prosperity without Growth: Foundations for the Economy of Tomorrow*. 2nd ed. London: Routledge. <https://doi.org/10.4324/9781315677453>.
- Jacques, Peter J., Riley E. Dunlap, and Mark Freeman. 2008. “The Organisation of Denial: Conservative Think Tanks and Environmental Scepticism.” *Environmental Politics* 17 (3): 349–85. <https://doi.org/10.1080/09644010802055576>.
- Kelman, Ilan, Sonja Ayeb-Karlsson, Kelly Rose-Clarke, Audrey Prost, Espen Ronneberg, Nicola Wheeler, and Nicholas Watts. 2021. “A Review of Mental Health and Wellbeing under Climate Change in Small Island Developing States (SIDS).” *Environmental Research Letters: ERL [Web Site]* 16 (3): 033007. <https://doi.org/10.1088/1748-9326/abe57d>.
- Ketcham, Christopher. 2019. “Esteban Servat on the Creation of EcoLeaks.” *Patagonia*, February 13, 2019. <https://eu.patagonia.com/nl/en/stories/the-first-eco-leak/story-71914.html>.
- Kleinman, Daniel Lee, and Steven P. Vallas. 2001. “Science, Capitalism, and the Rise of the ‘Knowledge Worker’: The Changing Structure of Knowledge Production in the United States.” *Theory and Society* 30 (4): 451–92.
- Kotcher, John E., Teresa A. Myers, Emily K. Vraga, Neil Stenhouse, and Edward W. Maibach. 2017. “Does Engagement in Advocacy Hurt the Credibility of Scientists? Results from a Randomized National Survey Experiment.” *Environmental Communication* 11 (3): 415–29. <https://doi.org/10.1080/17524032.2016.1275736>.
- Lamb, William F., Giulio Mattioli, Sebastian Levi, J. Timmons Roberts, Stuart Capstick, Felix Creutzig, Jan C. Minx, Finn Müller-Hansen, Trevor Culhane, and Julia K. Steinberger. 2020. “Discourses of Climate Delay.” *Global Sustainability* 3. <https://doi.org/10.1017/sus.2020.13>.
- Launer, John. 2021. “Medical Activism.” *Postgraduate Medical Journal* 97 (1151): 611–12. <https://doi.org/10.1136/postgradmedj-2021-140809>.
- Leal Filho, Walter, Mihaela Sima, Ayyoob Sharifi, Johannes M. Luetz, Amanda Lange Salvia, Mark Mifsud, Felicia Motunrayo Olooto, et al. 2021. “Handling Climate Change Education at Universities: An Overview.” *Environmental Sciences Europe* 33 (1): 109. <https://doi.org/10.1186/s12302-021-00552-5>.
- Lewandowsky, Stephan. 2020. “Climate Change Disinformation and How to Combat It,” 25.
- . 2021. “Climate Change Disinformation and How to Combat It.” *Annual Review of Public Health* 42 (1): 1–21. <https://doi.org/10.1146/annurev-publhealth-090419-102409>.
- Lucas, Adam. 2021. “Investigating Networks of Corporate Influence on Government Decision-Making: The Case of Australia’s Climate Change and Energy Policies.” *Energy Research & Social Science* 81 (November): 102271. <https://doi.org/10.1016/j.erss.2021.102271>.
- Mackenzie, Willie. 2018. “A Brief History of Commercial Whaling and Greenpeace.” Greenpeace International. 2018. <https://www.greenpeace.org/international/story/18307/history-commercial-whaling-greenpeace>.
- Marcus, Adam, and Ivan Oransky. 2017. “Should Scientists Engage in Activism?” The Conversation. 2017. <http://theconversation.com/should-scientists-engage-in-activism-72234>.
- Meine, Curt, Michael Soulé, and Reed F. Noss. 2006. “‘A Mission-Driven Discipline’: The

- Growth of Conservation Biology.” *Conservation Biology* 20 (3): 631–51. <https://doi.org/10.1111/j.1523-1739.2006.00449.x>.
- Miles-Novelo, Andreas, and Craig A. Anderson. 2019. “Climate Change and Psychology: Effects of Rapid Global Warming on Violence and Aggression.” *Current Climate Change Reports* 5 (1): 36–46. <https://doi.org/10.1007/s40641-019-00121-2>.
- Monbiot, George. 2022. “There’s a Simple Way to Unite Everyone behind Climate Justice – and It’s within Our Power.” *The Guardian*, June 24, 2022, sec. Opinion. <https://www.theguardian.com/commentisfree/2022/jun/24/rich-nations-climate-debt-cancelling-debts-emissions-global-debt-swap-campaign>.
- Moore, Kelly. 2009. *Disrupting Science: Social Movements, American Scientists, and the Politics of the Military, 1945-1975*. Princeton University Press. <https://doi.org/10.1515/9781400823802>.
- Mora, Camilo, Tristan McKenzie, Isabella M. Gaw, Jacqueline M. Dean, Hannah von Hammerstein, Tabatha A. Knudson, Renee O. Setter, et al. 2022. “Over Half of Known Human Pathogenic Diseases Can Be Aggravated by Climate Change.” *Nature Climate Change*, August, 1–7. <https://doi.org/10.1038/s41558-022-01426-1>.
- Mundy, Paul. 2021. “Meat Atlas: Facts and Figures about the Animals We Eat.” Heinrich Böll Stiftung, Friends of the Earth Europe, Bund für Umwelt und Naturschutz. <https://www.boell.de/sites/default/files/2021-09/Meat-Atlas-2021.pdf>.
- NAS, NAE and COSEMPUP. 2009. *On Being a Scientist: A Guide to Responsible Conduct in Research: Third Edition*. Washington (DC): National Academies Press (US). <http://www.ncbi.nlm.nih.gov/books/NBK214568/>.
- Nelson, Michael P., and John A. Vucetich. 2009. “On Advocacy by Environmental Scientists: What, Whether, Why, and How.” *Conservation Biology* 23 (5): 1090–1101.
- Nic Lughadha, Eimear, Steven P. Bachman, Tarciso C. C. Leão, Félix Forest, John M. Halley, Justin Moat, Carmen Acedo, et al. 2020. “Extinction Risk and Threats to Plants and Fungi.” *PLANTS, PEOPLE, PLANET* 2 (5): 389–408. <https://doi.org/10.1002/ppp3.10146>.
- Nielsen, Niklas Asp, and Frederik Thymark. 2021. “Forskere blokerer gaden foran Klimaministeriet: »Lyt til videnskaben!«.” October 25, 2021. <https://videnskab.dk/kultursamfund/forskere-blokerer-gaden-foran-klimaministeriet-lyt-videnskaben>.
- Nyhan, Brendan, Ethan Porter, and Thomas J. Wood. 2022. “Time and Skeptical Opinion Content Erode the Effects of Science Coverage on Climate Beliefs and Attitudes.” *Proceedings of the National Academy of Sciences* 119 (26): e2122069119. <https://doi.org/10.1073/pnas.2122069119>.
- Osborne, Margaret. 2022. “Scientists Stage Worldwide Climate Change Protests After IPCC Report.” *Smithsonian Magazine*, 2022. <https://www.smithsonianmag.com/smart-news/scientists-stage-worldwide-climate-protests-after-ipcc-report-180979913/>.
- Oswald, Yannick, Anne Owen, and Julia K Steinberger. 2020. “Large Inequality in International and Intranational Energy Footprints between Income Groups and across Consumption Categories.” *Nature Energy* 5 (3): 231–39.
- Pauling, Linus. 1958. *No More War!* New York: Dodd, Mead & Co.
- Pietrucci, Pamela, and Leah Ceccarelli. 2019. “Scientist Citizens: Rhetoric and Responsibility in L’Aquila.” *Rhetoric and Public Affairs* 22 (1): 95–128. <https://doi.org/10.14321/rhetpublaffa.22.1.0095>.
- Pyšek, Petr, Philip E. Hulme, Dan Simberloff, Sven Bacher, Tim M. Blackburn, James T. Carlton, Wayne Dawson, et al. 2020. “Scientists’ Warning on Invasive Alien Species.” *Biological Reviews* 95 (6): 1511–34. <https://doi.org/10.1111/brv.12627>.
- Raymond, Gabby. 2018. “Here’s Why the Endangered Species Act Was Created in the First Place.” *Time*, 2018. <https://time.com/5345913/endangered-species-act-history/>.
- Real Media. 2020. “Scientist Rebellion Throw Paint at The Royal Society - Real Media - The

- View From Below.” Real Media. 2020. <https://realmedia.press/scientist-rebellion-royal-society/>.
- Ripple, William J, Christopher Wolf, Thomas M Newsome, Phoebe Barnard, and William R Moomaw. 2020. “World Scientists’ Warning of a Climate Emergency.” *BioScience* 70 (1): 8–12. <https://doi.org/10.1093/biosci/biz088>.
- Ripple, William J., Christopher Wolf, Thomas M. Newsome, Mauro Galetti, Mohammed Alamgir, Eileen Crist, Mahmoud I. Mahmoud, William F. Laurance, and 364 scientist signatories from 184 countries 15. 2017. “World Scientists’ Warning to Humanity: A Second Notice.” *BioScience* 67 (12): 1026–28. <https://doi.org/10.1093/biosci/bix125>.
- Robottom, Ian, and Paul Hart. 1995. “Behaviorist EE Research: Environmentalism as Individualism.” *The Journal of Environmental Education* 26 (2): 5–9. <https://doi.org/10.1080/00958964.1995.9941433>.
- Rojas-Downing, M. Melissa, A. Pouyan Nejadhashemi, Timothy Harrigan, and Sean A. Woznicki. 2017. “Climate Change and Livestock: Impacts, Adaptation, and Mitigation.” *Climate Risk Management* 16 (January): 145–63. <https://doi.org/10.1016/j.crm.2017.02.001>.
- Romanello, Marina, Alice McGushin, Claudia Di Napoli, Paul Drummond, Nick Hughes, Louis Jamart, Harry Kennard, et al. 2021. “The 2021 Report of the Lancet Countdown on Health and Climate Change: Code Red for a Healthy Future.” *The Lancet* 398 (10311): 1619–62. [https://doi.org/10.1016/S0140-6736\(21\)01787-6](https://doi.org/10.1016/S0140-6736(21)01787-6).
- Royal College of Psychiatrists. 2021. “Position Statement PS03/21: Our Planet’s Climate and Ecological Emergency.” <https://www.rcpsych.ac.uk/docs/default-source/improving-care/better-mh-policy/position-statements/position-statement-ps03-21-climate-and-ecological-emergencies-2021.pdf>.
- Russell, Bertrand, Albert Einstein, Max Born, Percy W. Bridgman, Leopold Infeld, Frederic Joliot-Curie, Herman J. Muller, et al. 1955. “The Russell-Einstein Manifesto,” 1955. <https://pugwash.org/1955/07/09/statement-manifesto/>.
- Salomon, Anne K., Ken Lertzman, Kelly Brown, Kii’iljuus Barbara Wilson, Dave Secord, and Iain McKechnie. 2018. “Democratizing Conservation Science and Practice.” *Ecology and Society* 23 (1). <https://www.jstor.org/stable/26799032>.
- Schlenker, Wolfram, and Michael J. Roberts. 2009. “Nonlinear Temperature Effects Indicate Severe Damages to U.S. Crop Yields under Climate Change.” *Proceedings of the National Academy of Sciences* 106 (37): 15594–98. <https://doi.org/10.1073/pnas.0906865106>.
- Schmalzer, Sigrid, Daniel S. Chard, and Alyssa Botelho. 2018. *Science for the People: Documents from America’s Movement of Radical Scientists*. Amherst: University of Massachusetts Press. <https://muse.jhu.edu/book/59565>.
- Schmeller, Dirk S., Franck Courchamp, and Gerry Killeen. 2020. “Biodiversity Loss, Emerging Pathogens and Human Health Risks.” *Biodiversity and Conservation* 29 (11): 3095–3102. <https://doi.org/10.1007/s10531-020-02021-6>.
- Schmelzer, Matthias, Andrea Vetter, and Aaron Vansintjan. 2022. *The Future Is Degrowth: A Guide to a World Beyond Capitalism*. Verso.
- Schmolke, Amelie, Pernille Thorbek, Donald L. DeAngelis, and Volker Grimm. 2010. “Ecological Models Supporting Environmental Decision Making: A Strategy for the Future.” *Trends in Ecology & Evolution* 25 (8): 479–86. <https://doi.org/10.1016/j.tree.2010.05.001>.
- Smaje, Chris. 2020. *A Small Farm Future: Making the Case for a Society Built around Local Economies, Self-Provisioning, Agricultural Diversity and a Shared Earth*. Chelsea Green Publishing.
- Smith, Graham. 2009. *Democratic Innovations: Designing Institutions for Citizen Participation*. Theories of Institutional Design. Cambridge: Cambridge University Press. <https://doi.org/10.1017/CBO9780511609848>.

- Soulé, Michael E. 1985. "What Is Conservation Biology?" *BioScience* 35 (11): 727–34. <https://doi.org/10.2307/1310054>.
- Stein, Sharon, Cash Ahenakew, Elwood Jimmy, Vanessa De Oliveira Andreotti, Will Valley, Sarah Amsler, and Bill Calhoun. 2021. *Developing Stamina for Decolonizing Higher Education: A Workbook for Non-Indigenous People*.
- Steinberger, Julia. 2019. "A Postmortem for Survival: On Science, Failure and Action on Climate Change." *Age of Awareness* (blog). May 8, 2019. <https://medium.com/age-of-awareness/a-postmortem-for-survival-on-science-failure-and-action-on-climate-change-35636c79971e>.
- . 2022. "The Kids Are Not OK » Yale Climate Connections." Yale Climate Connections. May 15, 2022. <http://yaleclimateconnections.org/2022/05/the-kids-are-not-ok/>.
- Stengers, Isabelle. 2018. *Another Science Is Possible: A Manifesto for Slow Science*. John Wiley & Sons.
- Stevenson, Robert B., Jennifer Nicholls, and Hilary Whitehouse. 2017. "What Is Climate Change Education?" *Curriculum Perspectives* 37 (1): 67–71. <https://doi.org/10.1007/s41297-017-0015-9>.
- Stoddard, Isak, Kevin Anderson, Stuart Capstick, Wim Carton, Joanna Depledge, Keri Facer, Clair Gough, et al. 2021. "Three Decades of Climate Mitigation: Why Haven't We Bent the Global Emissions Curve?" *Annual Review of Environment and Resources* 46 (1): 653–89.
- Susser, Ezra, and Michaeline Bresnahan. 2001. "Origins of Epidemiology." *Annals of the New York Academy of Sciences* 954 (1): 6–18. <https://doi.org/10.1111/j.1749-6632.2001.tb02743.x>.
- Thackeray, Stephen J., Sharon A. Robinson, Pete Smith, Rhea Bruno, Miko U. F. Kirschbaum, Carl Bernacchi, Maria Byrne, et al. 2020. "Civil Disobedience Movements Such as School Strike for the Climate Are Raising Public Awareness of the Climate Change Emergency." *Global Change Biology* 26 (3): 1042–44. <https://doi.org/10.1111/gcb.14978>.
- Thomas, Abel, and Roshan Deshmukh. 2019. "Beard Grooming Market Size, Share & Trends |Industry Forecast - 2026." Allied Market Research. 2019. <https://www.alliedmarketresearch.com/beard-grooming-market>.
- Thompson, R., R. Hornigold, L. Page, and T. Waite. 2018. "Associations between High Ambient Temperatures and Heat Waves with Mental Health Outcomes: A Systematic Review." *Public Health* 161 (August): 171–91. <https://doi.org/10.1016/j.puhe.2018.06.008>.
- Thompson, Tosin. 2021. "Scientist Rebellion: Researchers Join Protesters at COP26." *Nature* 599 (7885): 357–357. <https://doi.org/10.1038/d41586-021-03430-5>.
- Tigchelaar, Michelle, David S. Battisti, Rosamond L. Naylor, and Deepak K. Ray. 2018. "Future Warming Increases Probability of Globally Synchronized Maize Production Shocks." *Proceedings of the National Academy of Sciences* 115 (26): 6644–49. <https://doi.org/10.1073/pnas.1718031115>.
- Tollefson, Jeff. 2020. "Why Deforestation and Extinctions Make Pandemics More Likely." *Nature* 584 (7820): 175–76. <https://doi.org/10.1038/d41586-020-02341-1>.
- UNO. 2021. "Guterres: The IPCC Report Is a Code Red for Humanity." United Nations Western Europe. August 9, 2021. <https://unric.org/en/guterres-the-ipcc-report-is-a-code-red-for-humanity/>.
- Veríssimo, Diogo, Thomas Pienkowski, Melissa Arias, Laure Cugnière, Hunter Doughty, Mirjam Hazenbosch, Emiel de Lange, Annalyse Moskeland, and Molly Grace. 2020. "Ethical Publishing in Biodiversity Conservation Science." *Conservation & Society* 18 (3): 220–25.
- Vicedo-Cabrera, A. M., N. Scovronick, F. Sera, D. Royé, R. Schneider, A. Tobias, C. Astrom, et al. 2021. "The Burden of Heat-Related Mortality Attributable to Recent Human-Induced Climate Change." *Nature Climate Change* 11 (6): 492–500.

- <https://doi.org/10.1038/s41558-021-01058-x>.
- Volkstimme. 2022. "Hörsaal der Uni Leipzig weiterhin von Klima-Aktivisten besetzt." May 12, 2022. <https://www.volksstimme.de/deutschland-und-welt/hoersaal-der-uni-leipzig-weiterhin-von-klima-aktivisten-besetzt-3377784>.
- Wagner, David L. 2020. "Insect Declines in the Anthropocene." *Annual Review of Entomology* 65 (1): 457–80. <https://doi.org/10.1146/annurev-ento-011019-025151>.
- Wahl, Daniel. 2016. *Designing Regenerative Cultures*. Triarchy Press.
- Waldron, Anthony, Vanessa Adams, James Allan, Andy Arnell, Greg Asner, Scott Atkinson, Alessandro Baccini, et al. 2020. "Protecting 30% of the Planet for Nature: Costs, Benefits and Economic Implications."
- Wells, Thomas. 2018. "Academics Should Not Be Activists." *3 Quarks Daily* (blog). December 17, 2018. <https://3quarksdaily.com/3quarksdaily/2018/12/academics-should-not-be-activists.html>.
- WHO. 2020. "Mental Health Atlas 2020." <https://www.who.int/publications/i/item/9789240036703/>.
- Whyte, Kyle. 2018. "Settler Colonialism, Ecology, and Environmental Injustice." *Environment and Society* 9 (1): 125–44. <https://doi.org/10.3167/ares.2018.090109>.
- World Health Organization. 2021. "Climate Change and Health." 2021. <https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health>.
- Wright, Gerald. 2010. "Civil Resistance and Power Politics The Experience of Non-Violent Action from Gandhi to the Present." SAGE Publications Sage UK: London, England.
- WWF. 2020. "Living Planet Report 2020." <https://www.worldwildlife.org/publications/living-planet-report-2020>.
- Wynes, Seth, and Kimberly A Nicholas. 2017. "The Climate Mitigation Gap: Education and Government Recommendations Miss the Most Effective Individual Actions." *Environmental Research Letters* 12 (7): 074024. <https://doi.org/10.1088/1748-9326/aa7541>.
- Xu, Chi, Timothy A. Kohler, Timothy M. Lenton, Jens-Christian Svenning, and Marten Scheffer. 2020. "Future of the Human Climate Niche." *Proceedings of the National Academy of Sciences* 117 (21): 11350–55. <https://doi.org/10.1073/pnas.1910114117>.
- Young, Robert S. 2017. "Opinion | A Scientists' March on Washington Is a Bad Idea." *The New York Times*, January 31, 2017, sec. Opinion. <https://www.nytimes.com/2017/01/31/opinion/a-scientists-march-on-washington-is-a-bad-idea.html>.
- Zhao, Chuang, Bing Liu, Shilong Piao, Xuhui Wang, David B. Lobell, Yao Huang, Mengtian Huang, et al. 2017. "Temperature Increase Reduces Global Yields of Major Crops in Four Independent Estimates." *Proceedings of the National Academy of Sciences* 114 (35): 9326–31. <https://doi.org/10.1073/pnas.1701762114>.
- Zhao, Qi, Yuming Guo, Tingting Ye, Antonio Gasparrini, Shilu Tong, Ala Overcenco, Aleš Urban, et al. 2021. "Global, Regional, and National Burden of Mortality Associated with Non-Optimal Ambient Temperatures from 2000 to 2019: A Three-Stage Modelling Study." *The Lancet Planetary Health* 5 (7): e415–25. [https://doi.org/10.1016/S2542-5196\(21\)00081-4](https://doi.org/10.1016/S2542-5196(21)00081-4).