

POINT OF VIEW

The biospheric emergency calls for scientists to change tactics

Abstract: Our current economic and political structures have an increasingly devastating impact on the Earth's climate and ecosystems: we are facing a biospheric emergency, with catastrophic consequences for both humans and the natural world on which we depend. Life scientists – including biologists, medical scientists, psychologists and public health experts – have had a crucial role in documenting the impacts of this emergency, but they have failed to drive governments to take action in order to prevent the situation from getting worse. Here we, as members of the movement Scientist Rebellion, call on life scientists to re-embrace advocacy and activism – which were once hallmarks of academia – in order to highlight the urgency and necessity of systemic change across our societies. We particularly emphasise the need for scientists to engage in nonviolent civil resistance, a form of public engagement which has proven to be highly effective in social struggles throughout history.

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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 the study of 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*). Moreover, many species that are not immediately threatened by extinction are suffering population declines (*Wagner, 2020*). Through a combination of unfettered changes in land use, 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 planet will look like in the near future, as biodiversity loss is further compounded by climate breakdown (*IPBES, 2019*). The Secretary-General of the United Nations, António Guterres, recently stressed that “the evidence is irrefutable:

greenhouse gas emissions from fossil fuel burning and deforestation are choking our planet” (*United Nations, 2021*). The latest report from the Intergovernmental Panel on Climate Change (IPCC) asserts global warming is on track to exceed 2°C during this century (*IPCC, 2021*), and more recent estimates are even higher (*Climate Action Tracker, 2022*). Furthermore, research indicates that the human climate niche may dramatically shrink over the next fifty years, making large swaths of the planet incompatible with human survival, and thus 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 five million excess deaths annually (*Bressler, 2021; Zhao et al., 2021*), via massively increased risks of heat stress, droughts, crop collapses, outbreaks of diseases and other natural disasters (*WHO, 2021*). The effect of these climate and ecological crises is exacerbated in lower-income countries, where the capacity for response is substantially decreased due to centuries of colonial

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Competing interest: The authors declare that no competing interests exist.

Funding: See page 10

Reviewing Editor: Peter Rodgers, eLife, United Kingdom

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appropriation and resource depletion (**Fanning et al., 2022; Hickel et al., 2022**).

Life scientists have documented the extermination of species and the destruction of ecosystems in excruciating detail (**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, who have the power to stop this process. Even as researchers write countless warnings and reports on the biospheric emergency, the situation gets worse every year (**Ripple et al., 2020; Ripple et al., 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 life scientists are failing in our duty to effectively engage with society about the biospheric emergency. We emphasise how a focus on behaviours that maintain the status quo 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 that is 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 life 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, as members of the movement Scientist Rebellion, call on life scientists to address these challenges by rediscovering forms of advocacy and activism that were a distinctive feature of previous generations of academics. To help this effort, we describe how advocacy and activism can be integrated into our scholarly responsibilities – including outreach, teaching and research – without compromising our professional integrity.

Acknowledging failure

Life scientists study the natural world: its past, its present, its future, and its ongoing interactions with human society. In addition to producing knowledge, many scientists feel a duty to relay this knowledge to the public (**Douglas, 2009**). 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 et al., 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, so as to trigger the cultural and political mechanisms able to prevent further degradation and collapse of ecosystems worldwide (**Díaz et al., 2019; Ripple et al., 2017**). In its 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**), while 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, 2022c**).

Yet, our societies have not developed the radical, collective and co-ordinated systems change that a planetary-scale emergency would require. Given the level of urgency, it is critical to ask how effective scientific efforts have been at producing such change and/or at galvanising politicians to take action. Here we discuss five areas where we think life scientists have failed in this regard: biodiversity conservation; food security; global public health; mental health; and life sciences education and dissemination. Each area has garnered enormous attention from life scientists, yet the situation in each gets dramatically worse 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, which is increasingly morphing into a science of extinction and risk assessment (**Gardner and Bullock, 2021**). The biodiversity crisis garnered public attention in the 1960s with the publication of *Silent Spring* by Rachel Carson (**Carson, 1962**). The following decades saw some success stories, such as the Endangered Species Act in the US and the global ban on whaling, largely as a consequence of activism (**Raymond, 2018; Mackenzie, 2018**). Yet, these efforts were far from enough, and the preservation of biodiversity is currently 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 impact needed to stop (or even slow 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 the life-support systems 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, 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 (*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; Gourdji et al., 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*). 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; Gourdji et al., 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 et al., 2016*).

Global public health

The biospheric emergency is linked to the deterioration of human health, through increasing exposure to extreme climate events (*Romanello et al., 2021; Vicedo-Cabrera et al., 2021; Gasparrini et al., 2015*), and our decreasing ability to effectively respond to epidemics (*WHO, 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 et al., 2020; Carlson et al., 2022*). More than half of human pathogenic diseases are predicted to be aggravated by climate change. Emerging epidemics in livestock and crops, as well as direct effects of climate change 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 world getting ready for the impact that the biospheric emergency will have on global public health? The answer appears to be "no". Recent studies have highlighted a remarkable lack of preparedness

for future pandemics (*Gibb et al., 2020; Romanello et al., 2021*), with the last author on one of these studies (Kate Jones of UCL) painting a bleak picture: “We’ve been warning about this for decades. Nobody paid any attention” (*Tollefson, 2020*). Moreover, it is unusual for research programmes in public health and medicine to consider the potential impact of rising temperatures and extreme weather on public health. Similarly, policymakers are neglecting to account for premature deaths related to heat stress (*Gasparrini et al., 2015*), which has already claimed thousands of victims in 2022 (*Coi and Weise, 2022*).

Mental health

There are also growing concerns about the impact of the climate and ecological crises on mental health (*Hayward and Ayeb-Karlsson, 2021; Kelman et al., 2021; Royal College of Psychiatrists, 2021*). A recent IPCC report found that climate change has already had a negative impact on mental health around the world, and this is expected to get worse (*IPCC, 2022a*). To illustrate this, we performed a Web of Science search for research articles on the topics of “eco-anxiety,” “climate anxiety” and “ecological grief”, and found that these have skyrocketed in recent years: no articles were found for any year before 2010 and there were fewer than two articles per year between 2010 and 2017. However, there were 49 such articles in 2021, and as of 13 September the figure for 2022 was 43. Indeed, despite some taxonomic confusion (*Clayton, 2020*), studies suggest an increasing range of negative emotions are associated with awareness of climate change (*Brosch, 2021*). In the US, for example, a poll found that almost half of the adults aged 18–34 reported that the stress they feel about climate change affects their daily lives (*APA, 2020*). More frequent exposure to intense heat is also contributing to increased aggressivity and suicide rates (*Miles-Novelo and Anderson, 2019; 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*).

Life science education and dissemination

To top things off, universities do little to teach about the impacts that the climate and ecological crises will have on these subjects, and on the careers of the students who study them. Students are rarely taught about scientific advocacy or 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 responding to these crises via changes in individual behaviour rather than collective action and institutional accountability (*Wynes and Nicholas, 2017; Stevenson et al., 2017; Robottom and Hart, 1995*). Indeed, as higher education institutions have adopted corporate structures and goals (*Kleinman and Vallas, 2001*), they have shifted the blame to individuals, and disincentivized modes of collective action and organising. As a result, both staff and students are left feeling hopeless and defeated at a time when, in fact, systemic change is entirely within our grasp (*Stoddard et al., 2021*).

The consequences of the failure of scientific engagement

Whether we talk about threats to food security, global health or biodiversity, scientific messaging is either not getting through to the public (*de Bruin et al., 2021*), or is being drowned out by sophisticated misinformation campaigns (*Lewandowsky, 2020*). There are now entire think tanks dedicated to occluding or misinterpreting scientific findings related to the biospheric emergency (*Dunlap and Jacques, 2013; Jacques et al., 2008; Lamb et al., 2020; Lewandowsky, 2021*), and recent research highlights that accurate information about climate and ecology can easily be eroded by misinformation (*Nyhan et al., 2022*). To make matters worse, scientific responses to misinformation campaigns tend to be dispassionate and directed at those in power (who are keen to maintain the status quo), rather than passionate and directed at 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 in the way we engage with society about the biospheric emergency. What would such a change involve? Many scientists are now outlining a path forward which entails embracing advocacy and activism in academia (*Gardner and*

Wordley, 2019; Gardner et al., 2021; Capstick et al., 2022). Advocacy involves taking a specific public stance in support of a cause – in this case, climate and ecological action (**Jickling, 2003; Nelson and Vucetich, 2009**). Activism refers to particularly direct forms of advocacy, such as petitioning or protesting. One form of activism that has proven to be highly effective at garnering public support, especially when done peacefully and en masse, is civil resistance (**Chenoweth et al., 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 (for example, 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 (**Roberts and Ash, 2009; Chenoweth, 2021**).

Advocacy and activism 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 *On Being A Scientist*, a handbook published by the National Academies for Science, Engineering and Medicine in the United States: “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, COSEMPUP, 2009**).

Not everyone agrees that scientists should engage in advocacy and activism. Some have argued that scientists should not take normative stances on any subject, and should therefore limit themselves to informing politicians, policy-makers and the public about the ever-worsening state of life on Earth (**Wells, 2018; Young, 2017**). This argument assumes that science can ever exist outside the political arenas that frame how it 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 the 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, which aim to preserve the foundations supporting human and non-human life (**Soulé, 1985; Susser and Bresnahan, 2001; Meine et al., 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 responsibilities to society. 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**). Although 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 are, perhaps understandably, wary of damaging their credibility by getting involved in 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 to participate in policy advocacy, because of their scientific expertise (**Cologna et al., 2021**). Studies show that, when it comes to ecological activism, scientific objectivity is not inherently compromised by the political aspects of 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 alarmist has seriously impeded accurate and effective scientific reporting by, for example,

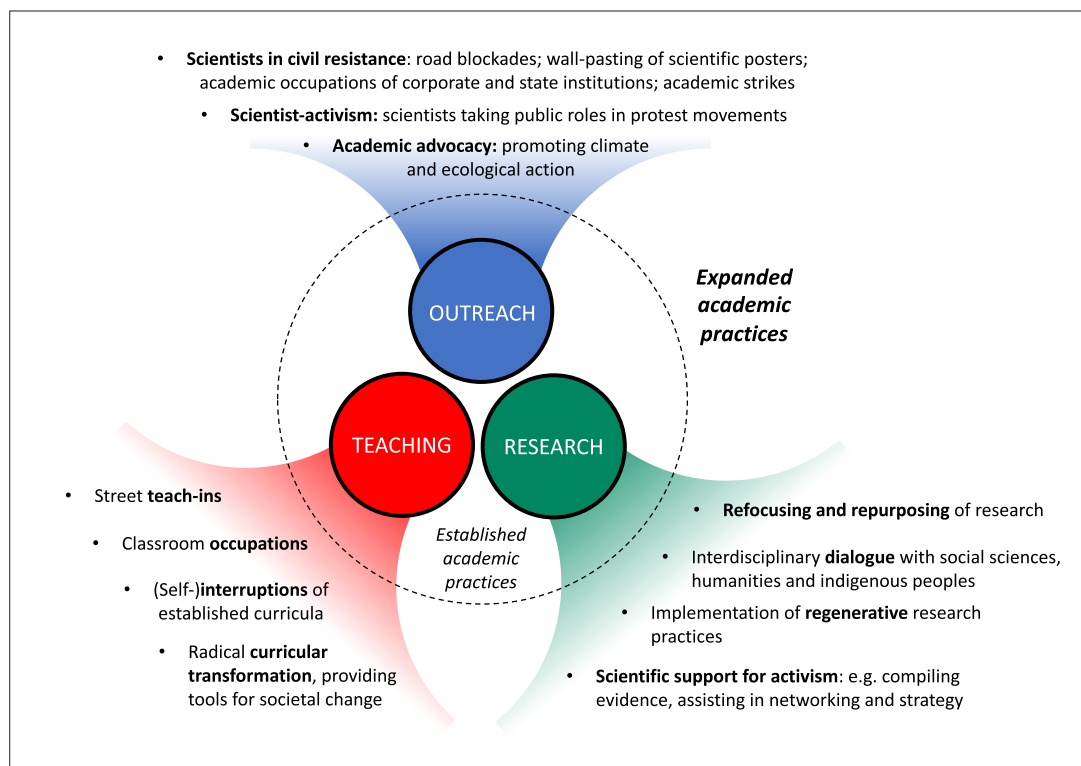


Figure 1. Examples of practices embracing advocacy and activism in academia. Scientists can expand the types of practices they carry out through their teaching, research and outreach, to better engage with the public and spur system change.

leading researchers to consistently underestimate the negative impacts of the climate and ecological crises (Brysse *et al.*, 2013). It has also led many to be dispassionate in their communications, when a more passionate and emotional approach would have been more effective (Brosch, 2021). As Marcus and Oransky wrote in 2017: "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 to include advocacy and activism

In this section we discuss how life scientists can include advocacy and activism in their work, in order to increase awareness of the climate and ecological crises, and to foster proactive responses to these crises. We will start with scientific outreach and then move to teaching and research (Figure 1).

Outreach is an essential aspect of being an academic, and connecting with the public can be done in many ways. In the biospheric

emergency, however, outreach must go beyond conventional ways of making scientific knowledge available to the public. Instead, we argue, scientists must actively participate in movements that are openly engaging with the emergency, via effective forms of direct action that can garner mass media attention (Chenoweth *et al.*, 2011; Chenoweth, 2020). Examples of such actions can include blockades of streets or bridges by scientists (Thompson, 2021), the occupation of corporate or government facilities (Chiarin, 2022), the pasting of pages from scientific papers and reports onto the walls of buildings (Gayle, 2022), and academic strikes (Ambjørseiet, 2022). As trusted communicators (Funk *et al.*, 2020), 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 attention and favour of the public if they are backed by biologists, ecologists or public health experts who can explain to journalists why new pipelines pose an existential risk to both nature and our civilization at large.

Similarly, our teaching practices can be adapted to embrace advocacy and activism, both inside and outside institutions of higher education. For

example, scientists can organise street teach-ins on the biospheric emergency while blocking traffic (*Nielsen and Thymark, 2021*), interrupt our own course curricula with talks about the biospheric emergency (*Steinberger, 2022*), or even occupy university classrooms (*Volkstimme, 2022*), thereby putting pressure on institutions to seriously mobilise their resources. The emergency ultimately requires 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 – that is, beyond the generation of data, models, papers and reports that are largely targeted at other academics (*Verissimo et al., 2020*). Instead of designing research programs for a world that will not exist anymore (*IPCC, 2021*), we can refocus and repurpose our research to develop tools that will help society to cope with the changes the biospheric emergency will cause. At the University of California San Diego, for example, the [Climate Psychology and Action Lab](#) is conducting research on socio-behavioural methods to help transition people away from climate skepticism or passivity, and into collective movements that confront fossil fuel extractivism and support renewable energies. Another recently launched initiative – [Faculty for a Future](#) – is helping academics transform their research, teaching, engagement, and institutions, so that they can, in turn, guide students and society into a more sustainable future. Along these lines, one of us (CJG) and colleagues recently argued that scientists can collaborate with activist groups, to help them collect evidence and improve strategies for movement-building and visibility (*Gardner et al., 2021*).

Scientists can also work to transition away from the unsustainable patterns of thinking in which academia has operated for decades, including a strong focus on conformism, competitiveness, opportunism and flexibility. These patterns of thinking are particularly dangerous in the biospheric emergency, as they have driven us to see technocratic approaches as the only solutions to humanity's problems. Instead scientists must be clear about the kind of knowledge science is capable of producing – including its failures and limitations – without shutting down the concerns of the non-academically-trained public (*Stengers, 2018*).

Most critically, research in the biospheric emergency needs to involve local stakeholders across

all stages of the process, including those who are most directly affected by climate and ecological breakdown (*Funtowicz and Ravetz, 1993*). It is vital for life scientists to listen to, collaborate with, and co-produce with social scientists, humanities scholars and indigenous communities: we must engage in meaningful dialogue with those who have been historically excluded or exploited by colonialism and neo-colonialism. For example, past and ongoing land-grabs, arrests and assassinations of Indigenous activists (*Global Witness, 2018*) have been key enablers of the climate and ecological crises, by silencing modes of thinking and understanding our world that questioned the socioeconomic norms violently imposed on other cultures (*Salomon et al., 2018; Stein et al., 2021*).

Speaking clearly

Finally, if we are to provide society with an honest assessment of the problems at hand, we cannot shy away from naming the forces behind the climate and ecological crises. Statements that vaguely ascribe land degradation or species loss to “human activities” are often found in the academic literature: however, not all humans are equally responsible, nor are all human activities destructive of nature. Indeed, the people and countries most affected by climate change and ecological breakdown are also the least responsible for them (*Gore, 2020; Oswald et al., 2020*). Overly vague statements draw attention away from the specific social, economic and political systems that are driving the biospheric emergency. These systems include:

- **Extractivist capitalism**, which prioritises unfettered economic growth and environmental exploitation over long-term social and ecological well-being (*Jackson, 2016; Hickel, 2020; Schmelzer et al., 2022*)
- **Settler-state colonialism**, which uses state-sanctioned violence to displace, imprison or murder indigenous land caretakers (*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*)
- **Citizen disenfranchisement**, which consists of barriers to public participation in democratic institutions, thereby perpetuating the inability of electoral politics to advance change (*Smith, 2009; Gerwin, 2020; Gilens and Page, 2014*).

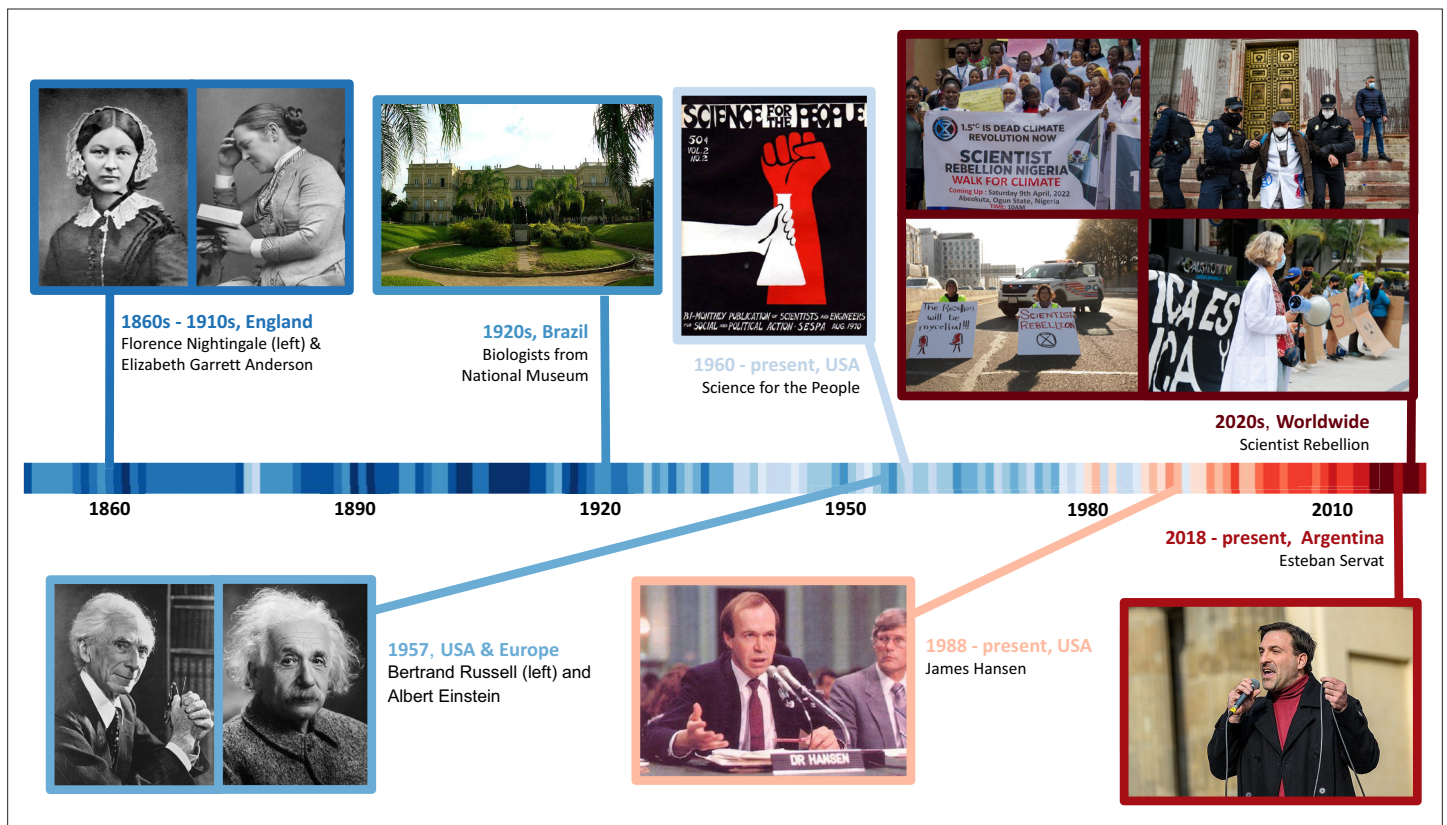


Figure 2. Scientists as activists through the ages. None of the tactics outlined in this article are new, and there is a long history of scientists engaging in activism. Examples include the work of statistician Florence Nightingale and physician Elizabeth Garrett Anderson in the women’s suffrage movement in the late nineteenth and early twentieth century; the activism of biologists from the National Museum in Brazil in favour of environmental protection in the 1920s; the Russell–Einstein manifesto of 1955 on the dangers on nuclear weapons; the Science for the People collective campaigning against war and for social justice in the United States in the late 1960s; the acts of civil resistance by climate scientist James Hansen to generate climate action; the work of biologist Esteban Servat building movements linking social justice and environmental abuse; and the Scientist Rebellion movement, which uses non-violent civil resistance in response to the climate and ecological crises. Image credits: Florence Nightingale: Henry Hering (CC0 1.0); Elizabeth Garrett Anderson: Walery (CC0 1.0); National Museum: Cyro A Silva (CC-BY 2.0); Bertrand Russell: Anefo (CC0 1.0); Albert Einstein: Orren Jack Turner (CC0 1.0); Science for the People (CC0 1.0); James Hansen: NASA (CC0 1.0); Esteban Servat: Stefan Müller (CC-BY 2.0); Scientist Rebellion Turtle Island (bottom left): Will Dickson (CC-BY 2.0); Scientist Rebellion Nigeria (top left): Obaloyin Timothy (CC-BY); Scientist Rebellion Spain (top right): Rodri Mínguez (CC0 1.0); Scientist Rebellion Panamá (bottom right): Viviano Romero, Renate Spooner (CC0 1.0); warming stripes: Ed Hawkins (CC-BY-SA).

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Ultimately, we must be aware 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. Scientists can 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; Steinberger, 2022).

Scientists in rebellion

Many scientists are already engaging in some of these forms of activism (Thompson, 2021). In

April 2022, for example, shortly after the publication of one of the IPCC reports, Scientist Rebellion mobilised over 1,500 scientists across 28 countries to highlight the dire global situation outlined by the report (IPCC, 2022b). Researchers of all scientific backgrounds risked arrest across all continents by participating in non-violent disruptive actions directed at governmental, scientific and corporate institutions deemed responsible for the climate and ecological crises (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 (*Harvey, 2021*). This fear was later shown to be founded (*Bordera, 2022*).

Though regaining momentum today, scientist activism is not new (*Figure 2*). 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 1960s and early 1970s, 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 et al., 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 (*Launer, 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 and Whitty, 2016*). More recently, the climatologist James Hansen has repeatedly engaged in activism, ever since his historic testimony to the US Senate in 1988 to raise public awareness about climate change and its effects on the biosphere. This activism 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 mobilisations across the world, highlighting links between social struggles in impoverished nations with environmental abuses by European and North American corporations (*Ketcham, 2019; Monbiot, 2022*).

Moving forwards

This article has focused on the life sciences. 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.

Acknowledgements


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 (<https://www.scientistrebellion.com/>) for the inspiration to write this piece.

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Competing interests: The authors declare that no competing interests exist.

Received 07 September 2022

Accepted 19 October 2022

Published 07 November 2022

Funding

No external funding was received for this work.

Data availability

N/A.

References

- Albert JS**, Destouni G, Duke-Sylvester SM, Magurran AE, Oberdorff T, Reis RE, Winemiller KO, Ripple WJ. 2021. Scientists' warning to humanity on the freshwater biodiversity crisis. *Ambio* **50**:85–94. DOI: <https://doi.org/10.1007/s13280-020-01318-8>, PMID: 32040746
- Allen J**. 2019. *Scientists, Students, and Society* (March 4, Anniversary Edition). MIT Press.
- Ambjørseiet T**. 2022. Forskere og aktivister streiket for klima. <https://underdusken.no/klima-ntnu-streik/forskere-og-aktivister-streiket-for-klima/303204> [Accessed June 2, 2022].
- 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> [Accessed September 20, 2022].
- Arora Nk**. 2019. Impact of climate change on agriculture production and its sustainable solutions. *Environmental Sustainability* **2**:95–96. DOI: <https://doi.org/10.1007/s42398-019-00078-w>
- Benessia A**, De Marchi B. 2017. When the earth shakes and science with it the management and communication of uncertainty in the L'Aquila earthquake. *Futures* **91**:35–45. DOI: <https://doi.org/10.1016/j.futures.2016.11.011>
- Bennett H**, Macmillan A, Jones R, Blaiklock A, McMillan J. 2020. Should health professionals participate in civil disobedience in response to the climate change health emergency? *Lancet* **395**:304–308. DOI: [https://doi.org/10.1016/S0140-6736\(19\)32985-X](https://doi.org/10.1016/S0140-6736(19)32985-X), PMID: 31818491
- Berrang-Ford L**, Sietsma AJ, Callaghan M, Minx JC, Scheelbeek PFD, Haddaway NR, Haines A, Dangour AD. 2021. Systematic mapping of global research on climate and health: a machine learning review. *The Lancet. Planetary Health* **5**:e514–e525. DOI: [https://doi.org/10.1016/S2542-5196\(21\)00179-0](https://doi.org/10.1016/S2542-5196(21)00179-0), PMID: 34270917
- Bordera Juan**. 2022. How the Corporate Interests and Political Elites Watered down the World's Most Important Climate Report. <https://mronline.org/2022/04/27/how-the-corporate-interests-and-political-elites-watered-down-the-worlds-most-important-climate-report> [Accessed April 27, 2022].
- Bradshaw CJA**, Ehrlich PR, Beattie A, Ceballos G, Crist E, Diamond J, Dirzo R, Ehrlich AH, Harte J, Harte ME, Pyke G, Raven PH, Ripple WJ, Saltré F, Turnbull C, Wackernagel M, Blumstein DT. 2021. Underestimating the challenges of avoiding a ghastly future. *Frontiers in Conservation Science* **1**:e19. DOI: <https://doi.org/10.3389/fcosc.2020.615419>, PMID: 35663143
- Bressler Rd**. 2021. The mortality cost of carbon. *Nature Communications* **12**:4467. DOI: <https://doi.org/10.1038/s41467-021-24487-w>, PMID: 34326326
- Brosch T**. 2021. Affect and emotions as drivers of climate change perception and action: a review. *Current Opinion in Behavioral Sciences* **42**:15–21. DOI: <https://doi.org/10.1016/j.cobeha.2021.02.001>
- Bryner J**. 2013. NASA Climate Scientist Arrested in Pipeline Protest. <https://www.livescience.com/27117-nasa-climate-scientist-arrest.html> [Accessed February 14, 2013].
- Brysse K**, Oreskes N, O'Reilly J, Oppenheimer M. 2013. Climate change prediction: erring on the side of least drama? *Global Environmental Change* **23**:327–337. DOI: <https://doi.org/10.1016/j.gloenvcha.2012.10.008>
- Capstick S**, Thierry A, Cox E, Berglund O, Westlake S, Steinberger JK. 2022. Civil disobedience by scientists helps press for urgent climate action. *Nature Climate Change* **12**:773–774. DOI: <https://doi.org/10.1038/s41558-022-01461-y>
- Carlson CJ**, Albery GF, Merow C, Trisos CH, Zipfel CM, Eskew EA, Olival KJ, Ross N, Bansal S. 2022. Climate change increases cross-species viral transmission risk. *Nature* **607**:555–562. DOI: <https://doi.org/10.1038/s41586-022-04788-w>, PMID: 35483403
- Carson R**. 1962. *Silent Spring*. Boston: Houghton Mifflin.
- Cavicchioli R**, Ripple WJ, Timmis KN, Azam F, Bakken LR, Baylis M, Behrenfeld MJ, Boetius A, Boyd PW, Classen AT, Crowther TW, Danovaro R, Foreman CM, Huisman J, Hutchins DA, Jansson JK, Karl DM, Koskella B, Mark Welch DB, Martiny JBH, et al. 2019. Scientists' warning to humanity: microorganisms and climate change. *Nature Reviews. Microbiology* **17**:569–586. DOI: <https://doi.org/10.1038/s41579-019-0222-5>, PMID: 31213707
- Chenoweth E**, Stephan MJ, Stephan M. 2011. *Why Civil Resistance Works: The Strategic Logic of Nonviolent Conflict*. Columbia University Press.
- Chenoweth E**. 2020. The future of nonviolent resistance. *Journal of Democracy* **31**:69–84. DOI: <https://doi.org/10.1353/jod.2020.0046>
- Chenoweth E**. 2021. Civil Resistance: What Everyone Needs to Know. <https://whateveryoneneedstoknow>.

- [com/view/10.1093/wentk/9780190244392.001.0001/wentk-9780190244392](https://doi.org/10.1093/wentk/9780190244392.001.0001/wentk-9780190244392) [Accessed February 4, 2021].
- Chiarin M.** 2022. Clima, ricercatori si incatenano davanti alla raffineria di eni a marghera. <https://nuovavenezia.gelocal.it/venezia/cronaca/2022/04/06/news/clima-ricercatori-si-incatenano-davanti-alla-raffineria-di-eni-a-marghera-1.41354461> [Accessed April 6, 2022].
- Choudry A.** 2020. Reflections on academia, activism, and the politics of knowledge and learning. *The International Journal of Human Rights* **24**:28–45. DOI: <https://doi.org/10.1080/13642987.2019.1630382>
- Clayton S.** 2020. Climate anxiety: psychological responses to climate change. *Journal of Anxiety Disorders* **74**:102263. DOI: <https://doi.org/10.1016/j.janxdis.2020.102263>, PMID: 32623280
- 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> [Accessed June 3, 2022].
- Coi G, Weise Z.** 2022. Excess deaths surged as heat wave hit europe. <https://www.politico.eu/article/excess-death-surged-heat-wave-hit-europe> [Accessed March 8, 2022].
- Cologna V, Knutti R, Oreskes N, Siegrist M.** 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**:024011. DOI: <https://doi.org/10.1088/1748-9326/abd4ac>
- Convention on Biological Diversity.** 2020. Global Biodiversity Outlook 5. <https://www.cbd.int/gbo5> [Accessed August 18, 2020].
- Cordier T, Alonso-Sáez L, Apothéoz-Perret-Gentil L, Aylagas E, Bohan DA, Bouchez A, Chariton A, Creer S, Frühe L, Keck F, Keeley N, Laroche O, Leese F, Pochon X, Stoeck T, Pawlowski J, Lanzén A.** 2021. Ecosystems monitoring powered by environmental genomics: a review of current strategies with an implementation roadmap. *Molecular Ecology* **30**:2937–2958. DOI: <https://doi.org/10.1111/mec.15472>, PMID: 32416615
- Cox R.** 2007. Nature’s “ crisis disciplines”: does environmental communication have an ethical duty? *Environmental Communication* **1**:5–20. DOI: <https://doi.org/10.1080/17524030701333948>
- Cunsolo A, Ellis NR.** 2018. Ecological grief as a mental health response to climate change-related loss. *Nature Climate Change* **8**:275–281. DOI: <https://doi.org/10.1038/s41558-018-0092-2>
- Dai A.** 2013. Increasing drought under global warming in observations and models. *Nature Climate Change* **3**:52–58. DOI: <https://doi.org/10.1038/nclimate1633>
- de Bruin W, Rabinovich L, Weber K, Babboni M, Dean M, Ignon L.** 2021. Public understanding of climate change terminology. *Climatic Change* **167**:e83. DOI: <https://doi.org/10.1007/s10584-021-03183-0>
- DeLonge MS, Miles A, Carlisle L.** 2016. Investing in the transition to sustainable agriculture. *Environmental Science & Policy* **55**:266–273. DOI: <https://doi.org/10.1016/j.envsci.2015.09.013>
- Diaz S, Settele J, Brondizio ES, Ngo HT, Agard J, Arneth A, Balvanera P, Brauman KA, Butchart SHM, Chan KMA, Garibaldi LA, Ichii K, Liu J, Subramanian SM, Midgley GF, Miloslavich P, Molnár Z, Obura D, Pfaff A, Polasky S, et al.** 2019. Pervasive human-driven decline of life on earth points to the need for transformative change. *Science* **366**:eaax3100. DOI: <https://doi.org/10.1126/science.aax3100>, PMID: 31831642
- Douglas HE.** 2009. Science, Policy, and the Value-Free Ideal. University of Pittsburgh Press. DOI: <https://doi.org/10.2307/j.ctt6wrc78>
- Douglas H.** 2021. Scientific freedom and social responsibility. Douglas H (Ed). *In Science, Freedom and Democracy*. New York, NY: Routledge. p. 68–87.
- Duarte R, Whitty D.** 2016. Activist Biology: The National Museum, Politics, and Nation Building in Brazil. University of Arizona Press. DOI: https://doi.org/10.2458/azu_uapress_9780816541706
- Dunlap RE, Jacques PJ.** 2013. Climate change denial books and conservative think tanks: exploring the connection. *The American Behavioral Scientist* **57**:699–731. DOI: <https://doi.org/10.1177/0002764213477096>, PMID: 24098056
- Fanning AL, O’Neill DW, Hickel J, Roux N.** 2022. The social shortfall and ecological overshoot of nations. *Nature Sustainability* **5**:26–36. DOI: <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> [Accessed December 4, 2019].
- FAO.** 2022. FAOSTAT. <https://www.fao.org/faostat/en/#data> [Accessed September 13, 2022].
- Fitzpatrick MC, Keller SR.** 2015. Ecological genomics meets community-level modelling of biodiversity: mapping the genomic landscape of current and future environmental adaptation. *Ecology Letters* **18**:1–16. DOI: <https://doi.org/10.1111/ele.12376>, PMID: 25270536
- Frickel S.** 2004a. Chemical Consequences: Environmental Mutagens, Scientist Activism, and the Rise of Genetic Toxicology. Rutgers University Press.
- Frickel S.** 2004b. Just science? organizing scientist activism in the US environmental justice movement. *Science as Culture* **13**:449–469. DOI: <https://doi.org/10.1080/0950543042000311814>
- Funk C, Tyson A, Kennedy B, Johnson C.** 2020. Scientists Are among the Most Trusted Groups in Society, Though Many Value Practical Experience over Expertise. <https://www.pewresearch.org/science/2020/09/29/scientists-are-among-the-most-trusted-groups-in-society-though-many-value-practical-experience-over-expertise> [Accessed September 29, 2020].
- Funtowicz SO, Ravetz JR.** 1993. Science for the post-normal age. *Futures* **25**:739–755. DOI: [https://doi.org/10.1016/0016-3287\(93\)90022-L](https://doi.org/10.1016/0016-3287(93)90022-L)
- Gardner CJ, Wordley CFR.** 2019. Scientists must act on our own warnings to humanity. *Nature Ecology & Evolution* **3**:1271–1272. DOI: <https://doi.org/10.1038/s41559-019-0979-y>, PMID: 31477847
- Gardner CJ, Bullock JM.** 2021. In the climate emergency, conservation must become survival ecology. *Frontiers in Conservation Science* **2**:e12. DOI: <https://doi.org/10.3389/fcosc.2021.659912>
- Gardner CJ, Thierry A, Rowlandson W, Steinberger JK.** 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**:e19. DOI: <https://doi.org/10.3389/frsus.2021.679019>

- Garnett ST**, Burgess ND, Fa JE, Fernández-Llamazares Á, Molnár Z, Robinson CJ, Watson JEM, Zander KK, Austin B, Brondizio ES, Collier NF, Duncan T, Ellis E, Geyle H, Jackson MV, Jonas H, Malmer P, McGowan B, Sivongxay A, Leiper I. 2018. A spatial overview of the global importance of indigenous lands for conservation. *Nature Sustainability* 1:369–374. DOI: <https://doi.org/10.1038/s41893-018-0100-6>
- Gasparrini A**, Guo Y, Hashizume M, Lavigne E, Zanobetti A, Schwartz J, Tobias A, Tong S, Rocklöv J, Forsberg B, Leone M, De Sario M, Bell ML, Guo YLL, Wu C, Kan H, Yi SM, de Sousa Zanotti Stagliorio Coelho M, Saldiva PHN, Honda Y, et al. 2015. Mortality risk attributable to high and low ambient temperature: a multicountry observational study. *Lancet* 386:369–375. DOI: [https://doi.org/10.1016/S0140-6736\(14\)62114-0](https://doi.org/10.1016/S0140-6736(14)62114-0), PMID: 26003380
- Gaupp F**, Hall J, Mitchell D, Dadson S. 2019. Increasing risks of multiple breadbasket failure under 1.5 and 2 °C global warming. *Agricultural Systems* 175:34–45. DOI: <https://doi.org/10.1016/j.agsy.2019.05.010>
- Gayle D**. 2022. XR scientists glue hands to business department in london climate protest. <https://www.theguardian.com/environment/2022/apr/13/xr-scientists-glue-hands-to-business-department-in-london-climate-protest> [Accessed April 13, 2022].
- Georgian S**, Hameed S, Morgan L, Amon DJ, Sumaila UR, Johns D, Ripple WJ. 2022. Scientists’ warning of an imperiled ocean. *Biological Conservation* 272:109595. DOI: <https://doi.org/10.1016/j.biocon.2022.109595>
- Gerwin M**. 2020. Citizens’ Assemblies: Guide to Democracy That Works. <https://citizensassemblies.org/download> [Accessed September 13, 2022].
- Gibb R**, Redding DW, Chin KQ, Donnelly CA, Blackburn TM, Newbold T, Jones KE. 2020. Zoonotic host diversity increases in human-dominated ecosystems. *Nature* 584:398–402. DOI: <https://doi.org/10.1038/s41586-020-2562-8>, PMID: 32759999
- Gilens M**, Page BI. 2014. Testing theories of American politics: elites, interest groups, and average citizens. *Perspectives on Politics* 12:564–581. DOI: <https://doi.org/10.1017/S1537592714001595>
- Global Witness**. 2018. At What Cost? Irresponsible Business and the Murder of Land and Environmental Defenders in 2017. <https://apo.org.au/node/184396> [Accessed July 24, 2018].
- Gore T**. 2020. Confronting carbon inequality: putting climate justice at the heart of the COVID-19 recovery. <https://oxfamilibrary.openrepository.com/bitstream/handle/10546/621052/mb-confronting-carbon-inequality-210920-en.pdf> [Accessed September 21, 2020].
- Gourdji SM**, Sibley AM, Lobell DB. 2013. Global crop exposure to critical high temperatures in the reproductive period: historical trends and future projections. *Environmental Research Letters* 8:024041. DOI: <https://doi.org/10.1088/1748-9326/8/2/024041>
- Green AJK**. 2021. Challenging conventions—A perspective from within and without. *Frontiers in Sustainability* 2:e38. DOI: <https://doi.org/10.3389/frsus.2021.662038>
- Harvey F**. 2021. IPCC steps up warning on climate tipping points in leaked draft report. <https://www.theguardian.com/environment/2021/jun/23/climate-change-dangerous-thresholds-un-report> [Accessed June 23, 2022].
- Harvey C**. 2022. Scientists risk arrest to demand climate action. <https://www.scientificamerican.com/article/scientists-risk-arrest-to-demand-climate-action> [Accessed April 11, 2022].
- Hatfield JL**, Prueger JH. 2015. Temperature extremes: effect on plant growth and development. *Weather and Climate Extremes* 10:4–10. DOI: <https://doi.org/10.1016/j.wace.2015.08.001>
- Hayes K**, Blashki G, Wiseman J, Burke S, Reifels L. 2018. Climate change and mental health: risks, impacts and priority actions. *International Journal of Mental Health Systems* 12:28. DOI: <https://doi.org/10.1186/s13033-018-0210-6>, PMID: 29881451
- Hayward G**, Ayeb-Karlsson S. 2021. “Seeing with empty eyes”: A systems approach to understand climate change and mental health in Bangladesh. *Climatic Change* 165:1–30. DOI: <https://doi.org/10.1007/s10584-021-03053-9>
- Hickel J**. 2020. Less Is More: How Degrowth Will Save the World. Random House.
- Hickel J**, Dorninger C, Wieland H, Suwandi I. 2022. Imperialist appropriation in the world economy: drain from the global south through unequal exchange, 1990–2015. *Global Environmental Change* 73:102467. DOI: <https://doi.org/10.1016/j.gloenvcha.2022.102467>
- Hodgson JC**, Mott R, Baylis SM, Pham TT, Wotherspoon S, Kilpatrick AD, Raja Segaran R, Reid I, Terauds A, Koh LP, Yoccoz N. 2018. Drones count wildlife more accurately and precisely than humans. *Methods in Ecology and Evolution* 9:1160–1167. DOI: <https://doi.org/10.1111/2041-210X.12974>
- IATP, GRAIN, Heinrich Böll Stiftung**. 2017. Big Meat and Dairy’s Supersized Climate Footprint. <https://www.iatp.org/supersized-climate-footprint> [Accessed November 7, 2017].
- IPBES**. 2019. Global Assessment Report on Biodiversity and Ecosystem Services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. https://knowledge4policy.ec.europa.eu/publication/global-assessment-report-biodiversity-ecosystem-services-intergovernmental-science-0_en [Accessed March 31, 2022].
- 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. Cambridge University Press.
- IPCC**. 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. Cambridge University Press.
- IPCC**. 2022b. Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press.
- IPCC**. 2022c. FAQ 6: What Is Climate Resilient Development and How Do We Pursue It. IPCC. <https://www.ipcc.ch/report/ar6/wg2/about/frequently-asked-questions/keyfaq6>
- Isopp B**. 2015. Scientists who become activists: are they crossing a line? *Journal of Science*

- Communication* **14**:C03. DOI: <https://doi.org/10.22323/2.14020303>
- Jackson T.** 2016. Prosperity without Growth: Foundations for the Economy of Tomorrow. Routledge. DOI: <https://doi.org/10.4324/9781315677453>
- Jacques PJ,** Dunlap RE, Freeman M. 2008. The organisation of denial: conservative think tanks and environmental scepticism. *Environmental Politics* **17**:349–385. DOI: <https://doi.org/10.1080/09644010802055576>
- Jickling B.** 2003. Environmental education and environmental advocacy: revisited. *The Journal of Environmental Education* **34**:20–27. DOI: <https://doi.org/10.1080/00958960309603496>
- Kelman I,** Ayeb-Karlsson S, Rose-Clarke K, Prost A, Ronneberg E, Wheeler N, Watts N. 2021. A review of mental health and wellbeing under climate change in small island developing states (SIDS). *Environmental Research Letters* **16**:033007. DOI: <https://doi.org/10.1088/1748-9326/abe57d>, PMID: 34149865
- Ketcham C.** 2019. Esteban servat on the creation of ecoleaks [Patagonia]. <https://eu.patagonia.com/nl/en/stories/the-first-eco-leak/story-71914.html> [Accessed February 13, 2019].
- Kleinman DL,** Vallas SP. 2001. Science, capitalism, and the rise of the “knowledge worker” the changing structure of knowledge production in the United States. *Theory and Society* **30**:451–492. DOI: <https://doi.org/10.1023/A:1011815518959>
- Kotcher JE,** Myers TA, Vraga EK, Stenhouse N, Maibach EW. 2017. Does engagement in advocacy hurt the credibility of scientists? results from a randomized national survey experiment. *Environmental Communication* **11**:415–429. DOI: <https://doi.org/10.1080/17524032.2016.1275736>
- Lamb WF,** Mattioli G, Levi S, Roberts JT, Capstick S, Creutzig F, Minx JC, Müller-Hansen F, Culhane T, Steinberger JK. 2020. Discourses of climate delay. *Global Sustainability* **3**:e13. DOI: <https://doi.org/10.1017/sus.2020.13>
- Launer J.** 2021. Medical activism. *Postgraduate Medical Journal* **97**:611–612. DOI: <https://doi.org/10.1136/postgradmedj-2021-140809>, PMID: 34446506
- Leal Filho W,** Sima M, Sharifi A, Luetz JM, Salvia AL, Mifsud M, Olooto FM, Djekic I, Anholon R, Rampasso I, Kwabena Donkor F, Dinis MAP, Klavins M, Finnveden G, Chari MM, Molthan-Hill P, Mifsud A, Sen SK, Lokupitiya E. 2021. Handling climate change education at universities: an overview. *Environmental Sciences Europe* **33**:109. DOI: <https://doi.org/10.1186/s12302-021-00552-5>, PMID: 34603904
- Lewandowsky S.** 2020. Climate change, disinformation, and how to combat it. *SSRN Electronic Journal* **1**:773. DOI: <https://doi.org/10.2139/ssrn.3693773>
- Lewandowsky S.** 2021. Climate change disinformation and how to combat it. *Annual Review of Public Health* **42**:1–21. DOI: <https://doi.org/10.1146/annurev-publhealth-090419-102409>, PMID: 33355475
- Lucas A.** 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**:102271. DOI: <https://doi.org/10.1016/j.erss.2021.102271>
- Mackenzie W.** 2018. A brief history of commercial whaling and Greenpeace. <https://www.greenpeace.org/international/story/18307/history-commercial-whaling-greenpeace> [Accessed September 10, 2018].
- Marcus A,** Oransky I. 2017. Should Scientists Engage in Activism? <http://theconversation.com/should-scientists-engage-in-activism-72234> [Accessed February 7, 2017].
- Meine C,** Soulé M, Noss RE. 2006. “A mission-driven discipline”: the growth of *Conservation Biology*. *Conservation Biology* **20**:631–651. DOI: <https://doi.org/10.1111/j.1523-1739.2006.00449.x>, PMID: 16909546
- Miles-Novelo A,** Anderson CA. 2019. Climate change and psychology: effects of rapid global warming on violence and aggression. *Current Climate Change Reports* **5**:36–46. DOI: <https://doi.org/10.1007/s40641-019-00121-2>
- Monbiot G.** 2022. There’s a simple way to unite everyone behind climate justice – and it’s within our power. <https://www.theguardian.com/commentisfree/2022/jun/24/rich-nations-climate-debt-cancelling-debts-emissions-global-debt-swap-campaign> [Accessed September 9, 2022].
- Moore K.** 2009. *Disrupting Science: Social Movements, American Scientists, and the Politics of the Military, 1945-1975*. Princeton University Press. DOI: <https://doi.org/10.1515/9781400823802>
- Mora C,** McKenzie T, Gaw IM, Dean JM, von Hammerstein H, Knudson TA, Setter RO, Smith CZ, Webster KM, Patz JA, Franklin EC. 2022. Over half of known human pathogenic diseases can be aggravated by climate change. *Nature Climate Change* **12**:869–875. DOI: <https://doi.org/10.1038/s41558-022-01426-1>
- Mundy P.** 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://eu.boell.org/en/MeatAtlas>
- NAS, NAE, COSEMPUP.** 2009. *On Being A Scientist: A Guide to Responsible Conduct in Research*. National Academies Press.
- Nelson MP,** Vucetich JA. 2009. On advocacy by environmental scientists: what, whether, why, and how. *Conservation Biology* **23**:1090–1101. DOI: <https://doi.org/10.1111/j.1523-1739.2009.01250.x>, PMID: 19459889
- Nic Lughadha E,** Bachman SP, Leão TCC, Forest F, Halley JM, Moat J, Acedo C, Bacon KL, Brewer RFA, Gâteblé G, Gonçalves SC, Govaerts R, Hollingsworth PM, Krisai-Greilhuber I, Lirio EJ, Moore PGP, Negrão R, Onana JM, Rajaovelona LR, Razanajatovo H, et al. 2020. Extinction risk and threats to plants and fungi. *PLANTS, PEOPLE, PLANET* **2**:389–408. DOI: <https://doi.org/10.1002/ppp3.10146>
- Nielsen NA,** Thymark F. 2021. Forskere blokerer gaden foran klimaministeriet: »lyt til videnskaben. <https://videnskab.dk/kultur-samfund/forskere-blokerer-gaden-foran-klimaministeriet-lyt-videnskaben> [Accessed October 25, 2021].
- Nyhan B,** Porter E, Wood TJ. 2022. Time and skeptical opinion content erode the effects of science coverage on climate beliefs and attitudes. *PNAS* **119**:e2122069119. DOI: <https://doi.org/10.1073/pnas.2122069119>, PMID: 35727983
- Osborne M.** 2022. Scientists stage worldwide climate change protests after IPCC report. <https://www.smithsonianmag.com/smart-news/scientists-stage-worldwide-climate-protests-after-ipcc-report-180979913> [Accessed April 13, 2022].

- Oswald Y**, Owen A, Steinberger JK. 2020. Large inequality in international and intranational energy footprints between income groups and across consumption categories. *Nature Energy* **5**:231–239. DOI: <https://doi.org/10.1038/s41560-020-0579-8>
- Pauling L**. 1958. No More War. New York: Dodd, Mead & Co.
- Pietrucci P**, Ceccarelli L. 2019. Scientist citizens: rhetoric and responsibility in L'Aquila. *Rhetoric and Public Affairs* **22**:95–128. DOI: <https://doi.org/10.14321/rhetpublaffa.22.1.0095>
- Pyšek P**, Hulme PE, Simberloff D, Bacher S, Blackburn TM, Carlton JT, Dawson W, Essl F, Foxcroft LC, Genovesi P, Jeschke JM, Kühn I, Liebhold AM, Mandrak NE, Meyerson LA, Pauchard A, Pergl J, Roy HE, Seebens H, van Kleunen M, et al. 2020. Scientists' warning on invasive alien species. *Biological Reviews of the Cambridge Philosophical Society* **95**:1511–1534. DOI: <https://doi.org/10.1111/brv.12627>, PMID: 32588508
- Raymond G**. 2018. Here's why the Endangered Species Act was created in the first place. <https://time.com/5345913/endangered-species-act-history/> [Accessed October 31, 2022].
- Ripple WJ**, Wolf C, Newsome TM, Galetti M, Alamgir M, Crist E, Mahmoud MI, Laurence WF. 2017. World scientists' warning to humanity: A second notice. *Bioscience* **67**:1026–1028. DOI: <https://doi.org/10.1093/biosci/bix125>
- Ripple WJ**, Wolf C, Newsome TM, Barnard P, Moomaw WR. 2020. World scientists' warning of a climate emergency. *BioScience* **70**:8–12. DOI: <https://doi.org/10.1093/biosci/biz088>
- Roberts A**, Ash TG. 2009. Civil Resistance and Power Politics: The Experience of Non-Violent Action from Gandhi to the Present. Oxford University Press.
- Robottom I**, Hart P. 1995. Behaviorist research: environmentalism as individualism. *The Journal of Environmental Education* **26**:5–9. DOI: <https://doi.org/10.1080/00958964.1995.9941433>
- Rojas-Downing MM**, Nejadhashemi AP, Harrigan T, Woznicki SA. 2017. Climate change and livestock: impacts, adaptation, and mitigation. *Climate Risk Management* **16**:145–163. DOI: <https://doi.org/10.1016/j.crm.2017.02.001>
- Romanello M**, McGushin A, Di Napoli C, Drummond P, Hughes N, Jamart L, Kennard H, Lampard P, Solano Rodriguez B, Arnell N, Ayeb-Karlsson S, Belesova K, Cai W, Campbell-Lendrum D, Capstick S, Chambers J, Chu L, Ciampi L, Dalin C, Dasandi N, et al. 2021. The 2021 report of the Lancet Countdown on health and climate change: code red for a healthy future. *The Lancet* **398**:1619–1662. DOI: [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> [Accessed May 5, 2021].
- Russell B**, Einstein A, Born M, Bridgman PW, Infeld L, Joliot-Curie F, Muller HJ. 1955. The Russell-Einstein Manifesto. <https://pugwash.org/1955/07/09/statement-manifesto> [Accessed June 9, 1955].
- Salomon AK**, Lertzman K, Brown K, Secord D, McKechnie I. 2018. Democratizing conservation science and practice. *Ecology and Society* **23**:1. DOI: <https://doi.org/10.5751/ES-09980-230144>
- Schlenker W**, Roberts MJ. 2009. Nonlinear temperature effects indicate severe damages to U.S. crop yields under climate change. *PNAS* **106**:15594–15598. DOI: <https://doi.org/10.1073/pnas.0906865106>
- Schmalzer S**, Chard DS, Botelho A. 2018. Science for the People: Documents from America's Movement of Radical Scientists. University of Massachusetts Press.
- Schmeller DS**, Courchamp F, Killeen G. 2020. Biodiversity loss, emerging pathogens and human health risks. *Biodiversity and Conservation* **29**:3095–3102. DOI: <https://doi.org/10.1007/s10531-020-02021-6>, PMID: 32836920
- Schmelzer M**, Vetter A, Vansintjan A. 2022. The Future Is Degrowth: A Guide to A World Beyond Capitalism. Verso.
- Schmolke A**, Thorbek P, DeAngelis DL, Grimm V. 2010. Ecological models supporting environmental decision making: a strategy for the future. *Trends in Ecology & Evolution* **25**:479–486. DOI: <https://doi.org/10.1016/j.tree.2010.05.001>, PMID: 20605251
- Smaje C**. 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 G**. 2009. Democratic Innovations: Designing Institutions for Citizen Participation. Cambridge University Press. DOI: <https://doi.org/10.1017/CBO9780511609848>
- Soulé ME**. 1985. What is conservation biology? *BioScience* **35**:727–734. DOI: <https://doi.org/10.2307/1310054>
- Stein S**, Ahenakew C, Jimmy E, Andreotti VDO, Valley W, Amsler S, Calhoun B. 2021. Developing stamina for decolonizing higher education. A Workbook for Non-Indigenous People.
- Steinberger J**. 2019. A Postmortem for Survival: On Science, Failure and Action on Climate Change. <https://medium.com/age-of-awareness/a-postmortem-for-survival-on-science-failure-and-action-on-climate-change-35636c79971e> [Accessed April 14, 2019].
- Steinberger J**. 2022. The kids are not OK. <http://yaleclimateconnections.org/2022/05/the-kids-are-not-ok> [Accessed May 15, 2022].
- Stengers I**. 2018. Another Science Is Possible: A Manifesto for Slow Science. John Wiley & Sons.
- Stevenson RB**, Nicholls J, Whitehouse H. 2017. What is climate change education? *Curriculum Perspectives* **37**:67–71. DOI: <https://doi.org/10.1007/s41297-017-0015-9>
- Stoddard I**, Anderson K, Capstick S, Carton W, Depledge J, Facer K, Gough C, Hache F, Hoolohan C, Hultman M, Hällström N, Kartha S, Klinsky S, Kuchler M, Lövbrand E, Nasiritousi N, Newell P, Peters GP, Sokona Y, Stirling A, et al. 2021. Three decades of climate mitigation: why haven't we bent the global emissions curve? *Annual Review of Environment and Resources* **46**:653–689. DOI: <https://doi.org/10.1146/annurev-environ-012220-011104>
- Susser E**, Bresnahan M. 2001. Origins of epidemiology. *Annals of the New York Academy of Sciences* **954**:6–18. DOI: <https://doi.org/10.1111/j.1749-6632.2001.tb02743.x>, PMID: 11797866
- Thackeray SJ**, Robinson SA, Smith P, Bruno R, Kirschbaum MUF, Bernacchi C, Byrne M, Cheung W, Cotrufo MF, Gienapp P, Hartley S, Janssens I,

- Hefin Jones T, Kobayashi K, Luo Y, Penuelas J, Sage R, Suggett DJ, Way D, Long S. 2020. Civil disobedience movements such as school strike for the climate are raising public awareness of the climate change emergency. *Global Change Biology* **26**:1042–1044. DOI: <https://doi.org/10.1111/gcb.14978>, PMID: 31971648
- Thomas A, Deshmukh R. 2019. Beard grooming market size, share & trends | industry forecast - 2026. <https://www.alliedmarketresearch.com/beard-grooming-market> [Accessed November 19, 2019].
- Thompson R, Hornigold R, Page L, Waite T. 2018. Associations between high ambient temperatures and heat waves with mental health outcomes: A systematic review. *Public Health* **161**:171–191. DOI: <https://doi.org/10.1016/j.puhe.2018.06.008>, PMID: 30007545
- Thompson T. 2021. Scientist rebellion: researchers join protesters at COP26. *Nature* **599**:357. DOI: <https://doi.org/10.1038/d41586-021-03430-5>
- Tigchelaar M, Battisti DS, Naylor RL, Ray DK. 2018. Future warming increases probability of globally synchronized maize production shocks. *PNAS* **115**:6644–6649. DOI: <https://doi.org/10.1073/pnas.1718031115>, PMID: 29891651
- Tollefson J. 2020. Why deforestation and extinctions make pandemics more likely. *Nature* **584**:175–176. DOI: <https://doi.org/10.1038/d41586-020-02341-1>, PMID: 32770149
- United Nations. 2021. Guterres: the IPCC report is a code red for humanity. <https://unric.org/en/guterres-the-ipcc-report-is-a-code-red-for-humanity> [Accessed August 8, 2021].
- Verissimo D, Pienkowski T, Arias M, Cugnière L, Doughty H, Hazenbosch M, de Lange E, Moskeland A, Grace M. 2020. Ethical publishing in biodiversity conservation science. *Conservation and Society* **18**:220. DOI: https://doi.org/10.4103/cs.cs_19_56
- Vicedo-Cabrera AM, Scovronick N, Sera F, Royé D, Schneider R, Tobias A, Astrom C, Guo Y, Honda Y, Hondula DM, Abrutzky R, Tong S, de Sousa Zanotti Stagliorio Coelho M, Saldiva PHN, Lavigne E, Correa PM, Ortega NV, Kan H, Osorio S, Kyselý J, et al. 2021. The burden of heat-related mortality attributable to recent human-induced climate change. *Nature Climate Change* **11**:492–500. DOI: <https://doi.org/10.1038/s41558-021-01058-x>, PMID: 34221128
- Volkstimme. 2022. Hörsaal der uni leipzig weiterhin von klima-aktivisten besetzt. <https://www.volkstimme.de/deutschland-und-welt/hoersaal-der-uni-leipzig-weiterhin-von-klima-aktivisten-besetzt-3377784> [Accessed May 13, 2022].
- Wagner DL. 2020. Insect declines in the anthropocene. *Annual Review of Entomology* **65**:457–480. DOI: <https://doi.org/10.1146/annurev-ento-011019-025151>, PMID: 31610138
- Waldron A, Adams V, Allan J, Arnell A, Asner G, Atkinson S, Baccini A. 2020. Protecting 30% of the planet for nature: costs, benefits and economic implications. Global Biodiversity Framework.
- Wells T. 2018. Academics Should Not Be Activists. <https://3quarksdaily.com/3quarksdaily/2018/12/academics-should-not-be-activists.html> [Accessed December 17, 2018].
- WHO. 2020. Mental Health Atlas 2020. <https://www.who.int/publications/i/item/9789240036703> [Accessed October 8, 2021].
- WHO. 2021. Climate Change and Health. <https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health> [Accessed October 30, 2021].
- Whyte K. 2018. Settler colonialism, ecology, and environmental injustice. *Environment and Society* **9**:125–144. DOI: <https://doi.org/10.3167/ares.2018.090109>
- WWF. 2020. Living Planet Report 2020. <https://www.worldwildlife.org/publications/living-planet-report-2020> [Accessed September 10, 2020].
- Wynes S, Nicholas KA. 2017. The climate mitigation gap: education and government recommendations miss the most effective individual actions. *Environmental Research Letters* **12**:074024. DOI: <https://doi.org/10.1088/1748-9326/aa7541>
- Xu C, Kohler TA, Lenton TM, Svenning JC, Scheffer M. 2020. Future of the human climate niche. *PNAS* **117**:11350–11355. DOI: <https://doi.org/10.1073/pnas.1910114117>, PMID: 32366654
- Young RS. 2017. A scientists' march on Washington is a bad idea. <https://www.nytimes.com/2017/01/31/opinion/a-scientists-march-on-washington-is-a-bad-idea.html> [Accessed January 31, 2017].
- Zhao C, Liu B, Piao S, Wang X, Lobell DB, Huang Y, Huang M, Yao Y, Bassu S, Ciais P, Durand JL, Elliott J, Ewert F, Janssens IA, Li T, Lin E, Liu Q, Martre P, Müller C, Peng S, et al. 2017. Temperature increase reduces global yields of major crops in four independent estimates. *PNAS* **114**:9326–9331. DOI: <https://doi.org/10.1073/pnas.1701762114>, PMID: 28811375
- Zhao Q, Guo Y, Ye T, Gasparrini A, Tong S, Overcenco A, Urban A, Schneider A, Entezari A, Vicedo-Cabrera AM, Zanobetti A, Analitis A, Zeka A, Tobias A, Nunes B, Alahmad B, Armstrong B, Forsberg B, Pan SC, Íñiguez C, 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**:e415–e425. DOI: [https://doi.org/10.1016/S2542-5196\(21\)00081-4](https://doi.org/10.1016/S2542-5196(21)00081-4), PMID: 34245712