Earth 2020

An Insider's Guide to a Rapidly Changing Planet

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Knowing Earth

Sheila Jasanoff

The philosophers and scientists of the eighteenth-century Age of Enlightenment believed that increasing knowledge of how the world works would liberate humans from superstition, and that reason would follow learning. In its engagement with science, modern environmentalism seems to have turned back the clock on this view of Enlightenment. To be sure, environmentalism was born in partnership with science and technical expertise, but it achieved adulthood in controversy and matured in an era of growing skepticism and paralyzing uncertainty. Science and scientists, along with inventors and engineers, remain central to the environmental story, but few now believe that more science and better technology will enable humanity to become effective planetary stewards — as commanding captains of Spaceship Earth. Instead, the entanglement of science and environmental protection has been marked by advances and retreats, with science serving at times as a torch of illumination, and at others as a lightning rod for controversy. Unquestionably, advances in science have allowed us to know Earth, and our place within it, far differently than on the first Earth Day five decades ago. Changing knowledge, however, has not brought greater mastery, as optimists of that earlier era might have hoped. Instead, scientific knowledge today confronts humankind with the challenge of assuming greater responsibility for an Earth whose complex dynamics elude full understanding, and whose very capacity to sustain human life is seen by many as gravely threatened.

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In the rapidly industrializing nineteenth century, the urge to protect nature arose in an acutely emotional register; a sense of irreparable loss as nature's tranquil beauty was ravaged by the smoke, filth and noise of the machine age. Only gradually did people learn that producing goods on mass scales not only did violence to pristine landscapes, but also harmed the health and wellbeing of all living things and the ecological and biophysical systems that sustain them. Biologist and natural historian Rachel Carson is widely credited with sounding an alarm that could not go unheeded. *Silent Spring*, her 1962 broadside against chemical pesticides,[1] helped ignite a social movement, calling attention to the stealthy, lethal pathways by which human-made toxins indiscriminately accumulate in organisms far beyond the intended targets of industrial 'biocide'. Benign DDT (dichlorodiphenyltrichloroethane), once known as a potent weapon against malaria and typhus, turned in Carson's telling into a symbol of technological over-reach, decimating bird populations, causing cancer in test animals (though not demonstrably in humans) and coursing in mothers' milk. Chemicals joined nuclear radiation as invisible bearers of harm whose unforeseen and unpredictable impacts potentially outweighed their acclaimed economic and health benefits. These dangers could neither be sensed nor entirely guarded against; they made us all reluctant denizens of what the German sociologist Ulrich Beck called the 'risk society'.[2]

Rising awareness of chemical and nuclear risks in the 1960s proved to be a boon for the environmental sciences. Indeed, one can see the 1970s as a decade of achievement in the institutionalization of scientific studies of the environment as well as in environmental law and policy. The US federal government led the way in research with the formation of the National Institute of Environmental Health Sciences (1969) and the National Toxicology Program (1978), as well as expansions in the scientific capabilities of regulatory bodies such as the newly formed Environmental Protection Agency (EPA). Universities followed suit, creating new departments and programs to study the environment in all its dynamic variety. In the private sector, the Ford Foundation sponsored opportunities for lawyers and scientists to collaborate for environmental protection through grants to influential organizations such as the Natural Resources Defense Council and the Environmental Defense Fund. Companies, too, recognized a need to develop new forms of expertise to meet the burdens of information production and risk assessment created by the changing landscape of environmental law.

Despite a promising start, the end of the 1970s brought backlash against environmental expertise, especially in the United States. Alarmed by the increasingly close partnership between science and governmental regulation, industry representatives launched systematic attacks on the quality of regulatory science, questioning both its validity and the integrity of its practitioners.[3] Much of regulatory knowledge, opponents insisted, was predictive, speculative and drawn from questionable or indirect sources, such as animal tests to determine the likelihood of human cancer, or climate models to predict the rise in global temperatures. Critics charged that much of this science was not peer-reviewed or published in reputable journals. Without well-established paradigms to guide environmental research and risk assessment, and with almost infinite entry points for questioning the methods and assumptions underlying science-based policy, the EPA proved particularly vulnerable to the politics of the moment. Well supported by the Clinton and Obama administrations, but aggressively undermined during the presidencies of both George W. Bush Jr. and Donald Trump, the EPA lost its global leadership position in the delivery of reasoned, science-based environmental protection. One telling indicator of the EPA's declining influence and regulatory muscle was its persistent failure to implement the Toxic Substances Control Act, a federal law that most directly responded to the threats laid bare by *Silent Spring*.[4]

Despite much controversy, environmental science continued to make large strides, especially in its power to detect and explain planetary phenomena. A notable success story of the late twentieth century was the detection of the ozone hole in the mid-1980s, which offers perhaps the best example to date of the rapid and effective integration of science and policy.[5] In a 1974 article in *Nature*, future Nobel laureates F. Sherwood Rowland and Mario J. Molina published troubling findings about the likely effects of chlorofluorocarbons (CFCs) — widely used in refrigerators, air conditioners and spray cans — on the stratospheric ozone layer shielding Earth from harmful ultraviolet radiation. Subsequent observations confirmed their disturbing hypothesis and, in 1987, leading industrial nations signed the Montreal Protocol, an international pact to ban and phase out CFCs and other ozone-depleting chemicals.[6]

Scientific consensus in this case pulled global policy in its wake. By 2015, all members of the United Nations were on board with the agreement to phase out the harmful substances, and the 'hole' in the ozone layer is now showing signs of gradual recovery.

Successful as it was, the CFC story also carried warnings about the limits of scientific knowledge when confronting problems of global scale and huge economic consequence. For at least a decade before the Montreal Protocol, uncertainty and indeterminacy served as rallying points for industry opposition to a CFC phase-out, and the policy consensus proved anything but straightforward to implement. As late as 1986, DuPont, the largest producer of CFCs, still led industry efforts to discredit the science advanced by Rowland and Molina. The company changed its tune only after developing new profitable compounds in an emerging market for CFC substitutes. The Montreal Protocol itself was negotiated among a relatively small group of producer nations, and special provisions were needed to draw in developing countries that were, if anything, more dependent on cheap refrigerants.[7] Even then, production of fluorocarbons never completely ended, and periodic violations of the letter and spirit of the ozone accords continued well into the new century. The Montreal Protocol nonetheless stands as a significant achievement for enlightened environmental policy. A risk was identified, and its cause eliminated. The treaty garnered formal support from all of the world's nations, and potentially catastrophic consequences were averted because politics followed where the science pointed.

The story of climate science traces a less triumphalist narrative line. The science in this case focused on the effects of carbon-containing greenhouse gases (GHGs) on Earth's average surface temperature. The idea was not new. Around 1896, the Swedish physical chemist Svante Arrhenius posited for the first time that GHGs released by human activity would cause the Earth to warm. Simulating the internal dynamics of a greenhouse, GHG molecules would trap radiant heat from the Earth's surface, absorbing it into the atmosphere and directing more heat back toward the planet, thus making temperatures rise. Since those early speculations, more than a century ago, many observations have converged to establish the truth of Arrhenius' hypothesis as solidly as any major finding in earth and planetary sciences.

If it takes a village to ensure the well-being of young children, then it is hardly surprising that it took a massive, collective effort to establish the scientific facts of climate change. Since 1988, that work has been led by the Intergovernmental Panel on Climate Change (IPCC), a body created by the UN Environment Program and the World Meteorological Organization to assess the mountains of data on Earth's changing biophysical systems, and to clarify the nature and severity of those changes in relation to human well-being. Divided into three working groups — on science, impacts and policy — the IPCC has always insisted on its political neutrality. Its work, the IPCC repeatedly asserts, is policy-relevant but not policy-prescriptive. Yet, it soon became apparent that policy neutrality could hardly remain a realistic option if the IPCC's claims were to be taken at face value. Since its first Assessment Report (AR) in 1992, the IPCC has issued a total of five ARs (a sixth is in the offing), and many additional special reports on specific effects and assessment methods. The basic conclusion that human activities are heating the planet has hardened with each report, while warnings have become more urgent that Earth is headed toward a point of no return, with melting ice caps, unpredictable sea level rise and extreme weather patterns endangering billions of vulnerable lives around the globe. These dire scenarios motivate the evangelical fervor of today's climate activism, in which many scientists engage along with lay citizens.

Unlike the case of ozone depletion, political action on climate change failed to keep up with the urgency of the scientific predictions. In 2015, the nations participating in the UN Framework Convention on Climate Change (UNFCCC) agreed to implement national reductions in CO_2 emissions that would hold global temperature rise to 2°C or, better still, 1.5°C (the Paris Agreement, signed in 2016).[8] Just five years later, the lower target seemed almost unattainable, and none of the highest emitting countries appeared on track to meet their Paris obligations. Most shockingly, in the face of widespread criticism, US President Donald Trump withdrew his country from the Paris Agreement soon after his election, arguing that meeting the treaty obligations would harm the American economy, placing businesses and workers at an unfair disadvantage. That economic argument continues to sway an electorate that has become less skeptical about the fact of anthropogenic climate change and yet remains reluctant to make the economic sacrifices and lifestyle changes needed to significantly curb GHG emissions.

If genuine reductions in GHG emissions are to be achieved, humanity will need to harness not only science and technology, but also its collective moral will. The astronomer and gifted science popularizer Carl Sagan offered a foretaste of that thought in his 1994 book, *The Pale Blue Dot*.[9] The floating images of Planet Earth brought home to Sagan the smallness and isolation of human existence. There is no sign in the vastness of space that humanity's salvation will come from anywhere else other than Earth and its human inhabitants. Hence, this 'thin film of life on an obscure and solitary lump of rock and metal' has to care for itself. As Sagan observes, 'To me, it underscores our responsibility to deal more kindly with one another, and to preserve and cherish the pale blue dot, the only home we've ever known'.[10]

Even as climate action remains unsteady and contested, there are some indications that the industrial world has begun to accept another truth that would have seemed self-evident to our premodern ancestors, and to those outside the Judeo-Christian tradition: human beings do not stand above or apart from nature, but are instead deeply embedded within it. Environmental sciences have increasingly shown how collective human activities are altering planetary dynamics to the potential detriment of our own and other species. The very idea of the Anthropocene, a new geologic age marked by the human imprint on the planet, points to the inseparability of nature and culture.[11] Outside the contentious debate on fossil fuel use, these insights are fostering new forms of environmental responsibility and political engagement. The worldwide movement against single-use plastic products, for example, signals a desire to clean the oceans of debris that threatens marine life and ecosystems. Other large collective actions range from decreased meat consumption and nationwide tree-planting campaigns to youth movements challenging their elders' perceived indifference toward the disastrous implications of climate change. Scientific insights are woven into these movements for change. The young climate activist Greta Thunberg, the living face on movements like Fridays for Future, draws her moral conviction squarely from science as she sees it. But the connections between science and social movements are not direct; the influence of science on Thunberg and millions of others around the world are tied less to methodologically rigorous demonstrations than to the perception that living unsustainably on Earth is no longer ethically tenable.

What do these developments mean for environmental science and politics in the twenty-first century? Clearly, there is no question that more scientific knowledge is needed. If anything, a growing awareness of the interconnectedness of Earth's living and non-living systems heralds a new age of discovery across the entire spectrum of the environmental sciences. The rise of intersecting and hybrid fields, such as biogeochemistry and sustainability science, attest to scientists' recognition that new understanding will have to be sought at the intersections of older fields and outside the boundaries of traditional disciplines. The enormous power of computing and data science have opened up new possibilities for modeling Earth's future on scales and at levels of detail that were not imaginable fifty years ago. Inspired individual insight will still retain a place, as it always has in science, but the scientific future belongs increasingly to centers and collectives capable of drawing together knowledge from multiple fields.

The events of the past half-century have taught us that mere gains in scientific understanding will not translate into wise policies for the human future. To enable that translation, we will need to harness all we have learned about making knowledge actionable and persuasive. This means, in the first instance, understanding that the environmental sciences cannot exist purely in the realm of impartial facts, cordoned off from political discourse and moral imperatives. Scientists must learn to see that describing the world in new terms demands that we change our ways of living in the world, to accommodate both what science tells us *and* what it is unable to foresee. The politics of environmental science in the next half-century will have to build on the understanding that science and planetary stewardship are co-produced. Inevitably, the politics of the Anthropocene will also have to be a politics of precaution.

Endnotes

1. R. Carson, *Silent Spring*, New York: Houghton Mifflin, 1962.
2. U. Beck, *Risk Society: Towards a New Modernity*, London: Sage Publications, 1992.
3. S. Jasanoff, *The Fifth Branch: Science Advisers as Policymakers*, Cambridge, MA: Harvard University Press, 1990.
4. See also 'The Global Chemical Experiment' by Elsie Sunderland and Charlotte C. Wagner in this volume.
5. See also 'Air' by Jon Abbatt in this volume.
6. Available at https://ozone.unep.org/treaties/montreal-protocol-substances-deplete-ozone-layer/text
7. See also 'Politics and Law' by Elizabeth May in this volume.
8. Available at https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement
9. C. Sagan, *The Pale Blue Dot: A Vision of the Human Future in Space*, New York: Random House, 1994.
10. Ibid., at 3 and 7.
11. J. Purdy, *After Nature: A Politics for the Anthropocene*, Cambridge, MA: Harvard University Press, 2015.