


William Lee Steffen (1947-2023)

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Earth-system scientists and all those concerned with the future of the habitability conditions on the planet mourn the passing of Will Steffen on January 29th, 2023 (fig. 1). He was an outstanding scientist and a major figure in the Earth-system science, a scientific branch that crystallized in 1980s and 1990s by bringing together ecology, biology, oceanography and climate science. Furthermore, science has lost a vociferous advocate of science-based climate-change policies and on the urgency to adopt worldwide measures to mitigate what he thought was already a full-blown climate crisis.



Figure 1: Will Steffen.

Fonte: Martin Hedberg - <https://martinhedberg.se/3-will-steffen-anthropocene-great-acceleration-and-feedbacks>

Will Steffen was born in Nebraska, US, acquired his training as chemical engineering at the University of Missouri in Rolla and in chemistry at the University of Florida in Gainesville. He emigrated to Australia in the late 1970s to work as a postdoctoral fellow on X-ray crystallography at the Australian National University in Canberra. His eclectic background allowed him to tackle problems with increasing complexity and naturally led him to be invited to join the

International Geosphere-Biosphere Programme. This Programme ran from 1987 to 2015 under the auspices of the International Council of Scientific Unions aiming to understand the biological, chemical and physical processes that regulate the whole Earth System and to study the phenomenon of global change. From 1998 to 2004 Will Steffen served as its executive director. He also served as science adviser to the Australian Department of Climate Change and Energy Efficiency. He was a member of the advisory board of the Australian Bureau of Meteorology and worked with the Prime Minister's Science, Engineering and Innovation Council.

Will Steffen has helped to craft many ideas that were initially considered radical and are nowadays mainstream. These include the concept that the Anthropocene is a new geological era, following the Nobel Prize of Chemistry in 1995, Paul Crutzen, with whom he wrote what can be considered the definite paper on the matter (Steffen, Crutzen & McNeill, 2007). He later served as the science expert on the international Anthropocene Working Group, which gathered empirical data to establish the Anthropocene as a new chronostratigraphic unit of the Geologic Time Scale characterised by the dominance of the human activities. He was also at the core of the team that defended that the Anthropocene had started in early 1950s, when a significant increase in the environmental impact due to the population growth and the burning of fossil fuel took place, a period often referred to as the "Great Acceleration" (Steffen, Broadgate, Deutsch, Gaffney & Ludwig, 2015).

He was one of the main authors of the seminal 2009 *Nature* paper "A safe operating space for humanity" (Rockström et al., 2009), which discussed the fundamental concept of the "planetary boundaries", a set of parameters, whose values at present indicate how far the Earth System is operating with respect to the stable and safe values at the Holocene (the Safe Operating Space). At least 9 crucial parameters have already been identified: climate change; loss of biosphere integrity; depletion of stratospheric ozone; ocean acidification; fresh water consumption and global hydrological cycle; land system change; nitrogen and phosphorus flows to the biosphere and oceans; atmospheric aerosol loading; and chemical pollution and the release of novel entities (fig. 2). The follow up paper that appeared in the *Science* journal in 2015 (Steffen et al, 2015) further stressed the importance of closely tracking these parameters and showed how some of them could drive the Earth System into a new state. The importance of monitoring the planetary boundaries at the regional level was also discussed

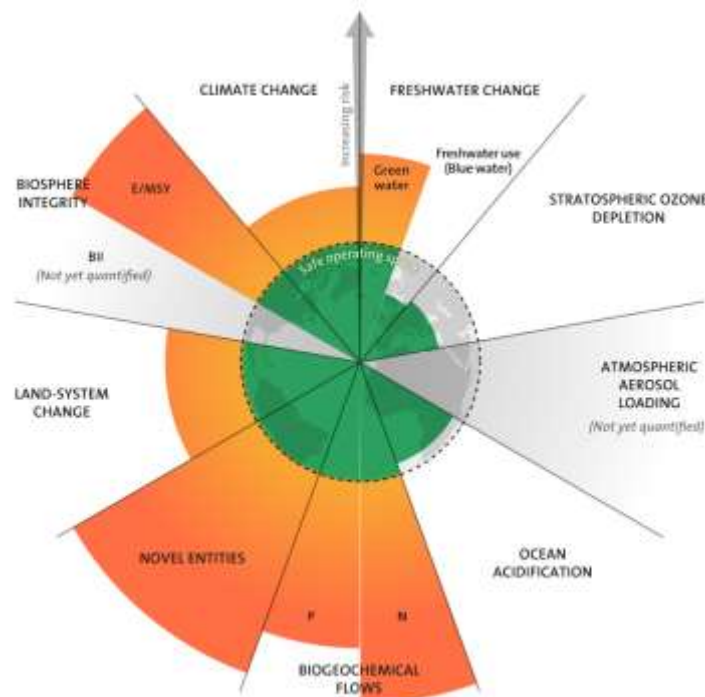


Figure 2: Planetary boundaries.

Fonte: Designed by Azote for Stockholm Resilience Centre - <https://www.stockholmresilience.org/research/planetary-boundaries.html>

Will Steffen led also the work on the trajectories of the Earth System in the Anthropocene which show how human activities reinforcing feedbacks are driving the system into a Hothouse Earth (Steffen et al., 2018), a regime in which its climate could no longer be stabilised. These contributions are the cornerstones of nowadays Earth-System Science, which was nicely reviewed by Will and collaborators in a *Nature* paper in 2020 (Steffen et al., 2020).

Will Steffen was also exemplary on the way scientists should get involved in matters of general interest. In fact, he challenged the Australian government in 2016 after it put pressure on the United Nations to censor all references on the impacts on the Great Barrier Reef, the Northern Territory's Kakadu National Park and the Tasmanias' forests. In a letter written in 2020 for a project that asked leading climate scientists about their view of the future, he expressed his anger and apprehension for the lack of effective measures to reduce emissions, for the greed of the fossil fuel elite, the lies of the Murdoch press and the weakness of the political leaders. He strongly advocated the need for stewardship measures to halt emissions and was well aware of the difficulties to reconcile contradicting views on how to implement them.

I had the privilege to meet Will Steffen in September 2018 when he visited Porto at the launch of the "Casa Comum da Humanidade", a project I was then involved with. Having had the opportunity to get to know Will was quite fortunate as it was through a work which he co-authored with Owen Gaffney in 2017 (Gaffney & Steffen, 2017) that I became aware of the importance of the so-called

Anthropocene equation. The knowledge of this elusive equation was argued to be crucial to understand the evolution and behaviour of the Earth System dominated by the forcing of the human activities. His approach and contributions prompted my interest on the subject and inspired our proposal for the Anthropocene equation (Bertolami & Francisco, 2018) and the ensued works (see, for instance: Bertolami, 2022). Will was generous enough to acknowledge our modest contribution as an example on how physics could help to achieve a deeper understanding of the machinery of the Earth System. We had then the opportunity to discuss on the matters that he was a world-class expert. This precious insight on his views was filmed by a team of the Porto's University (Universidade do Porto, 2018). Later, he was also interviewed by journalist Sandra Sousa for the Portuguese National Television (RTP2, 2021).

Will Steffen will be remembered for his calm, kindness, optimism and determination. He left us an impressive scientific legacy and his example will keep on inspiring those who hope for a brighter future for humankind.

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