



Summer has enjoyed hot days and warm nights with brilliant planets gleaming in the sky. On the day after the summer solstice, and beneath a bright blue sky, pyramidal orchids are flourishing in Northfield (near New Ash Green, Kent) June 23, 2018.

Prime Meridian (90) June 30, 2018

What does climate change mean, not only for our civilisation, but also for the fate of other civilisations elsewhere in our Galaxy?

We investigate a recent and thought-provoking claim published this month by scientists in the USA and Germany. We also look back on our own research and lectures, exploring implications for climate change for the Earth and other planets.

“Unless nature is perversely biased against civilizations like ours, we’re not the first one to appear.” Adam Frank.

From the Earth to the stars. What can our knowledge about the Earth and about human impacts on our planet tell us about the possibilities of other habitable planets. These are questions that are of keen interest to our team.

A new paper published in early June from the University of Rochester, New York, USA, raises several very interesting questions. This report has been reproduced in many places over in the news. This is an extremely thought-provoking and timely paper that brings together environmental concerns on Earth and attempts to discover other civilisations on Earth-like planets.

This is a fascinating combination of disciplines and, of course, this is also the area in which the Ecospheres Project is itself engaged. We are looking at this from a different perspective. Many journalists have faithfully quoted, but we are approaching this rather differently, as might be expected from our own research interests.

The lead author was Adam Frank with his colleague Jonathan Carroll-Nellenback, in the Department of Physics and Astronomy, University of Rochester, together with M. Alberti of the Department of Urban Design and Planning, University of Washington, Seattle, Washington, USA, and A. Kleidon at Max Planck Institute for Biogeochemistry, Jena, Germany.

Scientists are presently taking a lot of interest in the implications of what has been called the Anthropocene. The word had been used in various ways, but it reached the world stage after it was used by the Dutch chemist Paul Jozef Crutzen. Crutzen was notably given the Nobel Prize in 1995 for his research into the hole in the ozone layer. He and Eugene F. Stoermer (1934-2012) argued that the most recent section of the geological record should be recognised as a new geological episode during which the Earth has been significantly modified by human activity (Crutzen & Stoermer, 2000).

Crutzen, P. and Stoermer, E. F. (2000). The “Anthropocene.” *GBPNEWSLETTER* 41 1 The International Geosphere-Biosphere Programme (IGBP): A Study of Global Change of the International Council for Science (ICSU) May No. 41 2000, 17-18.

What are the implications of civilisations on other Earth-like planets, as they develop and grow and produce ever greater impacts on their own world? This is the process that is going on on Earth right now. The paper from the team at the University of Rochester is titled: *The Anthropocene Generalized: Evolution of Exo-Civilizations and Their Planetary Feedback* (Frank *et al.*, 2018).

It’s worth checking out also an outline on the University of Rochester website, “Alien apocalypse: Can any civilisation make it through climate change?” This is also presented on ScienceDaily June 4, 2018. There’s also a Rochester YouTube “Could Alien Civilisations Predict the Fate of our Planet? Also in *Astrobiology* 18:503-518. We have not reviewed the new book by Adam Frank “*Light of the Stars: Alien Worlds and the Fate of the Earth*” (W.W. Norton, June 2018).

Frank, A. *et al.* (2018). *Astrobiology* 18: 503-518. DOI:[10.1089/ast.2017.1671](https://doi.org/10.1089/ast.2017.1671).

Our own life-long academic and campaigning interests have actively explored problems of Earth stewardship. In late summer 2017, our set of discussions and debates, *Frontiers of Survival*, brought together interests of Earth events and the implications for other planets elsewhere in our Galaxy.

In one of our horizon-scanning papers whose purpose was to look at potential future areas of interest, I thought that it was overdue to flag up the fact that what we are doing down here on Earth, and undermining our natural world provides a sobering relations between reality and enthusiasm for terraforming other planets into be now beautiful living Earths.

My colleagues and I entered this particular arena some decades ago, and from a rather different angle. We were looking with scepticism at the concept of “terraforming.” This is the concept of converting other planets and moons into Earth-like homes for the human species.

The concept of converting barren planets into human-habitable worlds was mooted early by science fiction authors. The name is credited to John Stewart Williamson (1908-2006), whose pen name was “Will Stewart.” The Oxford English Dictionary (1997; M. Proffitt Ed.) quoted as examples:

“1949 'W. STEWART' in *Astounding Sci. Fiction* Feb. 15/1 I've got the Martian industrial trust interested in an atomic furnace to make synthetic terraforming diamonds.”

“1949 'W. STEWART' in *Astounding Sci. Fiction* Feb. 37/1 That little terraformed planetoid, outside the mines and drift, had been the base of supplies for Freedonia. *Ibid.*, Once old Bruce Banion . . hired Jim Drake to terraform it.”

This is how we put our case in *Frontiers of Survival*:

Terraforming Paradox I

Our civilisation has provided enormous benefits for our species. Down here on Earth, however, the destructive impact of our civilisation is undermining the natural life support systems upon which we depend for our survival. Many ecosystems are being lost before we have a chance to study them in detail. We cannot recreate them. This process, encouraged by economic and other societal pressures, has a momentum that is proving very difficult to resist.

Terraforming proponents assume that we will be able to create pristine habitable worlds occupied on a sustainable basis, with no such destructive pressures on their ecospheres.

Terraforming Paradox II

It is sometimes said that we need to terraform other planets so that we have somewhere to escape the environmental damage that we are doing to the Earth.

If we cannot reverse the damage that we have caused here, what reason is there to believe that we can create new habitable worlds?

How badly would we have to damage the Earth before it becomes easier to modify the presently hostile environments of other worlds in the Solar System than to repair the Earth's ecosphere?

The paper emphasised:

“Terraforming of other planets will be possible only if technological civilisation survives on Earth. Major threats to the well-being of civilisation are posed by both natural and anthropogenic climatic changes. They highlight the fact that it is not only the first order requirements of insolation, seas, breathable atmosphere and life that make a world habitable, but also the 'fine tuning' of environmental factors. The first task of planetary management will be to achieve a sound knowledge of the processes that maintain the current relatively equable climate of Earth. Civilisation has arisen during what appears to have been one of the comparatively brief, warm, interglacial episodes that have interrupted the more hostile glacial conditions of the Late Cenozoic. The return of glacial conditions would severely reduce the carrying capacity of the planet for human population. In contrast, the anthropogenic build-up of greenhouse gases in the atmosphere will, according to numerous current models, lead to a rapid global warming, and serious consequences for human societies.”

“Civilisation has grown in a haphazard fashion and now consists of nation states divided by philosophy, economic circumstances and competing national interests. How practicable is a global level of organisation that will be required to tackle, effectively, the problems outlined here? The establishment of a long-lived civilisation, enjoyed by the benefits of a stable, hospitable climate may prove to be no mean task.” Heath, 1989.

If you can't solve this huge problem, then we wouldn't be able to meaningfully terraform anything! We have a long, long way to go in graduation as planetary stewards, here or anywhere else. I wrote this paper because there was a real gap between different sections of the scientific community.

This is not to argue that terraforming is impossible, but rather to emphasise the immensity of the problem. It seems like hubris for we (self-styled) *Homo sapiens*, to imagine that our civilisation has, as yet, graduated from a destroyer into a creator.

Ways to live or die - our civilisation and others.

“In the face of climate change, deforestation and biodiversity loss, creating a sustainable version of civilization is one of humanity's most urgent tasks.”

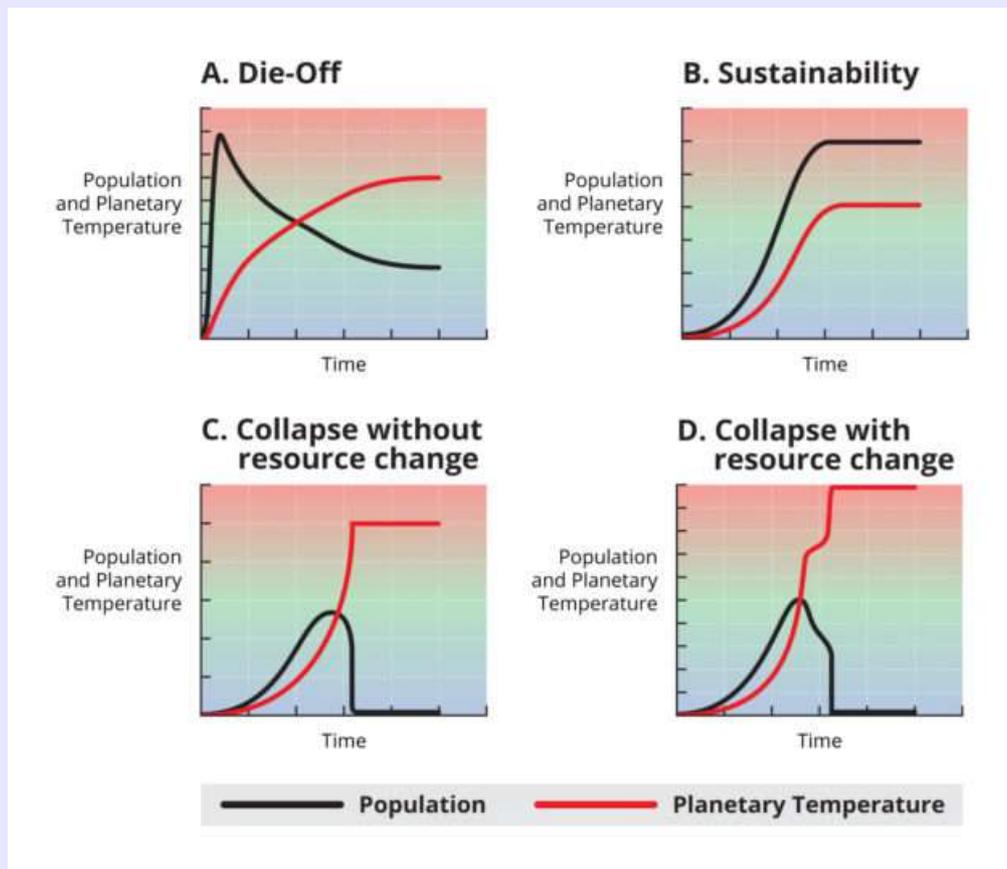
With great interest and appreciation, my colleagues and I recognise this work from Adam Frank at the University of Rochester and his co-workers, as another important dimension to the discussion between Earth stewardship and life beyond the Earth.

Frank's team has chosen four categories of civilisations (as taken from discussions and their paper):

1. Die-off: The population and the planet's state (indicated by something like its average temperature) rise very quickly. Eventually, the population peaks and then declines rapidly as the rising planetary temperature makes conditions harder to survive. A steady population level is achieved, but it's only a fraction of the peak population.
2. Sustainability: The population and the temperature rise but eventually both come to steady values without any catastrophic effects. This scenario occurs in the models when the population recognizes it is having a negative effect on the planet and switches from using high-impact resources, such as oil, to low-impact resources, such as solar energy.

3. Collapse without resource change: The population and temperature both rise rapidly until the population reaches a peak and drops precipitously. In these models civilization collapses, though it is not clear if the species itself completely dies out.

4. Collapse with resource change: The population and the temperature rise, but the population recognizes it is causing a problem and switches from high-impact resources to low-impact resources. Things appear to level off for a while, but the response turns out to have come too late, and the population collapses anyway.

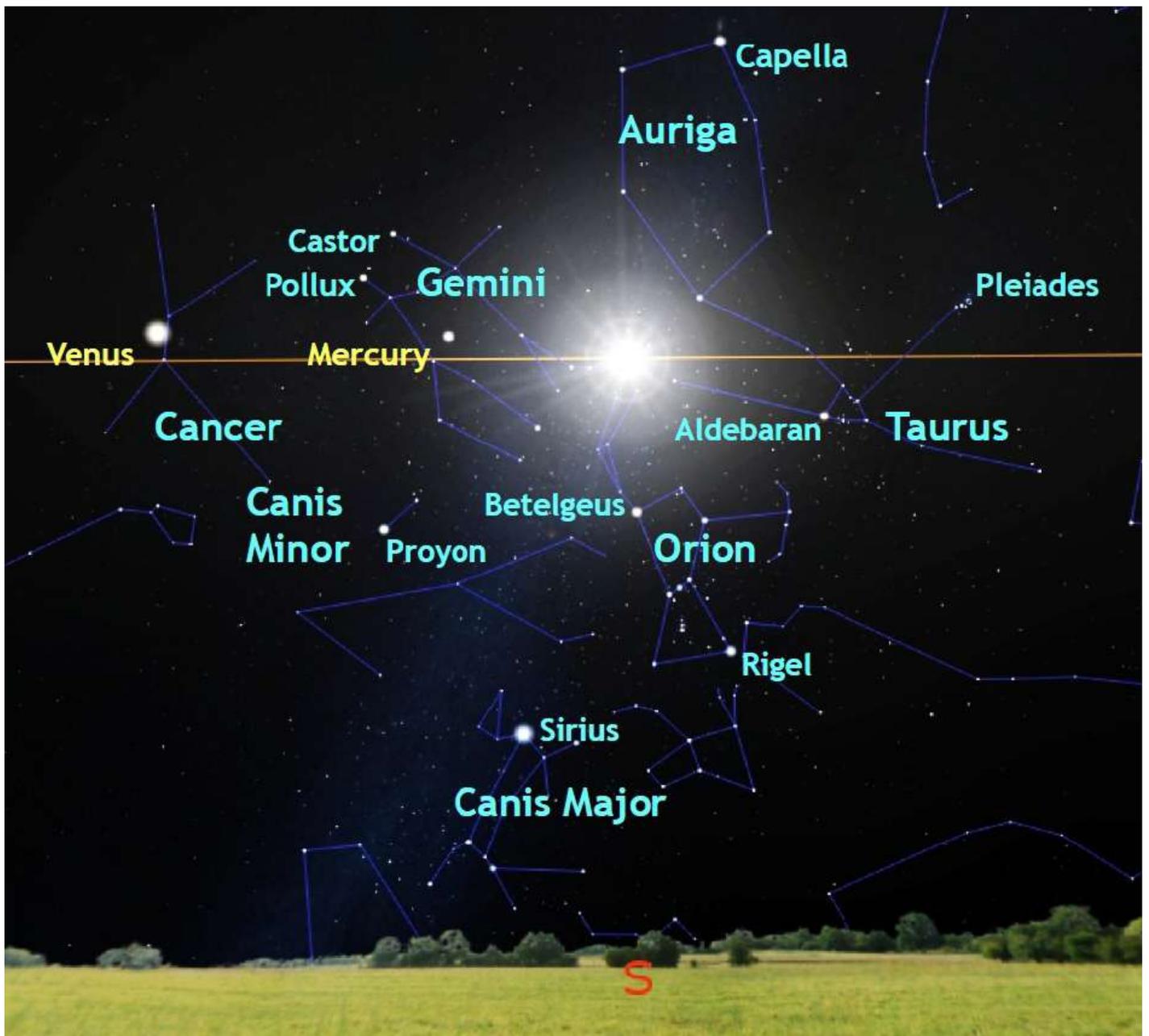


The University of Rochester observed:

“does every civilization that may have arisen in the cosmos last only a few centuries before it falls to the climate change it triggers?”

“In the face of climate change, deforestation and biodiversity loss, creating a sustainable version of civilization is one of humanity's most urgent tasks.”

One very interesting aspect of this paper was the use of Easter Island. Environmentalists have often argued that its people destroyed their natural resources, thus committed ecocide. This paper brought Easter Island, one of the most mysterious and dramatic places on Earth, together with the possible fates of alien civilisations. This engaged with ecological concerns on Earth and with the exploration of other Earth-like planets. This was a coup; a very effective promotion of science to a broad and global public. This team deserve congratulation for that. However, Easter Island is the subject of intense and highly contentious debate. We hope to look at that in a later discussion in PM. We will ask whether Easter Island ecocide is best taken as well-founded history or as a useful *parable*.



June 21, 2018 Summer solstice.

Northern Hemisphere.

Another milestone of the year has passed. The longest day is behind us, although the nights are still late and short.

The actual moment of the solstice was at 10.07 UT. The illustration above (re-labelled *Stellarium* image) shows the Sun in the middle of the day, simulates the appearance of the sky from Greenwich, South East England. The atmosphere has been removed to show locations of the planets and stars.

The Summer day-time sky is occupied by constellations that we see in the lengthy winter nights. The Sun lay in Gemini, but very close also to Taurus and Orion. The two planets inside the orbit of Earth, Venus and Mercury would have been visible in the night sky. Mercury was not easy to see, but Venus, brightest of the planets, as seen from Earth, has given us a great display during the summer evenings.



NASA's Solar Dynamics Observatory was launched in 2010, and orbits in an inclined geosynchronous orbit. The SDO sends back detailed images of the Sun at several sections of the spectrum. The image above was obtained on June 21, 2018. Maximum solar activity was in 2014 and the Sun is now heading for the bottom of the current solar minimum, expected in 2019-2020. The large sunspot AR2715 was carried out of sight (right) behind the Sun and no sunspots were seen on the side of our star rest of Earth, since June 28 to the end of the month.

Below: The Sun rises at Ash, Kent on the day of the Summer solstice.



Southern Hemisphere.

The South Pole was facing its winter solstice, with the Sun at its farthest below the horizon. These pictures were drawn from an Antarctic webcam. Images of the Amundsen-Scott South Pole Station were taken from the roof of the National Science Foundation's Atmospheric Research Observatory (ARO) which houses the Clean Air Facility of the National Oceanic and Atmospheric Administration's Earth System Research Laboratory.

The Aurora Australis favoured the webcam with an obliging display during the solstice. At 00:06:23 the notable star Alphard (above the red light), is the brightest star in the constellation of Hydra. About 180 light years away, it is three times more massive than the Sun and is evolving into a red giant. At 05:21:25, Jupiter, our Sun's largest planet, sat in the same part of the sky.





Saturn, second largest of the Sun's planets was the brightest object in the sky at 07:06:24. It can be seen at the very edge near the right.

Prime Meridian

Prime Meridian is published by the Ecospheres Project, a research and media collaboration.

This newsletter follows global environmental issues alongside the cycle of the seasons in South East England. It steps back to look at the Earth in its astronomical context and it pursues the search for other habitable worlds.

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During the last few months, the Ecospheres Project has enjoyed several discussions about potential collaborations. Our thanks to Veronica Mariquoe, Felipe Matias Salamanca Picón, Laura Elworthy and Elizabeth Gornall.

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