Can humans survive the Anthropocene?

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The Earth system

Imagine we could weigh all of the animals on the Earth's land surfaces. The creatures can be divided into three classes: wild animals, covering everything from elephants, camels and polar bears to rabbits, kangaroos and wolves; domesticated animals, including cows, sheep, pigs, cats and dogs; and human beings. If we weighed them all, worked out their mass measured in millions of tonnes, what would be the percentages falling into each of the three classes – wild, domesticated and human?

Canadian scientist Vaclav Smil has performed the calculation.[1] It turns out that humans account for 30 per cent of the total mass of all animals, and domesticated animals account for 67 per cent. That leaves all of the wild animals on the Earth's surface accounting for no more than three per cent. In the words of Smil: "The zoomass of wild vertebrates is now vanishingly small compared to the biomass of domestic animals". Wildlife documentaries showing vast herds of wildebeest sweeping across the plains are quite misleading, as are the Attenborough films that leave us with the impression there are many remote places out there where wildlife thrives.

Humans have radically changed not only the relative mass of wild creatures but also their distribution around the globe, driving out species and bringing exotic ones wherever they go. Scientists now believe that we are in the midst of a sixth mass extinction – a period in Earth's history "when abnormally large numbers of species die out simultaneously or within a limited time frame" – with the rate of extinction now 100-1000 times faster than the natural one.

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[1] Vaclav Smil, Harvesting the Biosphere: The Human Impact, *Population and Development Review* 37(4): 613-36, December 2011. The proportions are of mass measures in dry weight.

The transformative impact of human activity on the globe can be illustrated in many ways. Each year humans shift ten times more rock and soil around the Earth than do the great natural processes of erosion and weathering. Dam-building since the 1930s has held back enough water to keep the oceans three centimeters lower than they otherwise would be.

But the greatest impact is due to human-induced climate change. For 200 years humans have been putting into the atmosphere carbon that in the form of coal and oil had lain immobile for millions of years beneath the ground. Some of the extra carbon dioxide emitted into the atmosphere will stay there for hundreds of years, some for a thousand years and more.

Over time most of the extra carbon dioxide we are putting into the atmosphere will be absorbed by the oceans, as carbonic acid, rendering them more acidic. Since the start of the Industrial Revolution the acidity of the oceans has risen by nearly a third. This change in the chemical composition of the world's oceans is effectively permanent. It is expected to have profound effects on marine life because it makes it harder for calcification to occur, affecting corals, oysters and crustaceans like crabs and krill.

We cannot isolate the climate system from the other components of the Earth system. We are discovering that changes in the atmosphere affect not just the weather but also the Earth's hydrosphere (the watery parts), the biosphere (living creatures) and even the lithosphere (the Earth's crust). They are all linked by the great natural cycles and processes that make the Earth so dynamic. In short, with global warming, not merely the climate but everything is in play. As geologist Bill McGuire put it: "So complex and entangled is the Earth System that, looking to the future, nothing can be regarded as immune to the influence of anthropogenic warming."

As the earth warms ice masses like Greenland's are melting, which changes the distribution of water around the globe, with less at the poles. Ice masses are enormously heavy and as they thaw the Earth's crust rebounds, with seismic and even volcanic effects. The changing distribution of mass around the globe will actually slow the planet's rotation speed. This effect is tiny but I make the point to emphasize just how total is the impact of humans.

The Anthropocene

So profound has been the influence of humans that Earth system scientists have recently proposed that the Earth has entered a new geological epoch, the Anthropocene, the Age of Humans, defined by the fact that the "human imprint on the global environment has now become so large and active that it rivals some of the great forces of Nature in its impact on the functioning of the Earth system".[2]

It must be stressed that we are not simply describing the further spread of human impact but a shift in its nature. As Earth scientist James Syvitski writes:

> At some point, we graduated from adapting to our environment to making it adapt to us. … But now we regularly decelerate and accelerate natural processes, focus energy in extraordinary ways and alter, destroy or create ecosystems.[3]

So the Anthropocene is not defined by the broadening impact of humans on the environment, but by active human interference in the processes that govern the geological evolution of the planet.

The arrival of the Anthropocene is usually dated from the end of the 18th century with the onset of the Industrial Revolution in Britain, when greenhouse gas emissions began their modern upward trajectory and the human population began to expand. More recently, Earth system scientists have identified the years immediately following the Second World War as the start of the "Great Acceleration", a point of inflexion at which growth rates of consumption, resource use and waste generation shifted onto a much steeper path.

The advent of the Anthropocene marks the end of the Holocene, a 10,000-year epoch of remarkable climatic stability and clemency. The Holocene itself was preceded by hundreds of thousands of years of climatic chaos. Modern humans have been around for 200,000 years. For the first 190,000 or so years the weather was changeable, a jagged history of ice ages, little ice ages and warming periods, with massive ice sheets at times covering most of the northern hemisphere then retreating for short periods of

[2] Will Steffen, Jacques Grinevald, Paul Crutzen and John McNeil, 'The Anthropocene: Conceptual and historical perspectives', *Philosophical Transactions of the Royal Society A* 369 (2011), pp. 842–67
[3] James Syvitski, Anthropocene: An epoch of our making, *Global Change*, Issue 78, March 2012, p. 14

a few thousand years before returning to drive human populations to a precarious existence in the cold or to epic migrations towards the equator. Although humans survived these wild swings, at times populations were decimated.

But some 10,000 years ago the climate stabilized around an average temperature very close to the modern one prior to the influence of industrialization. The Holocene's mild and unusually stable climate permitted human civilisation to flourish. Settled agriculture, impossible in the climatic gyrations of previous times, emerged. Some 7,000 years ago, in the "cradle of civilization", the river valleys that drain into the Persian Gulf, the new conditions permitted not only settled communities but the development of the wheel, writing, mathematics, legal codes, centralized government and social strata.

The Holocene made these things possible. In the Holocene humans were able to free themselves from the dictates of nature and to flourish on the Earth. Now we are told the Holocene's halcyon millennia have come to an end. Humans have flourished so successfully in the sympathetic environment of the last 10,000 years that we have shifted Earth's geological arc. The effects of human activity on the climate system (warming, melting ice masses, acidification of the oceans and rising seas) are expected to last hundreds of thousands of years.

We are entering what is known as a hyper-thermal, an interval marked by a massive increase in atmospheric carbon and the hot, sticky and volatile world that goes with it. Once again "natural" processes – now, in fact, a new natural-human hybrid – will drive wild swings in the climate.

The Anthropocene was first so named by an atmospheric chemist, Paul Crutzen, rather than a geologist or palaeontologist, which alerts us to the fact that the new geological epoch is like no other episode in Earth history. All previous geological divisions have been identified by digging into rock strata. The evidence for the Anthropocene, on the other hand, is not to be found in the rock strata (at least, not yet) but in the atmosphere, the oceans, the soils and the biota, in other words in the domain occupied by humans where the forces operating are unlike anything that has come before.

The Earth's 4.5 billion year history is officially divided into ages, epochs, periods, eras and eons according to a range of criteria developed by geologists, and marked on the geological time scale, a scale approved by the International Commission on Stratigraphy and familiar to us in terms like Jurassic, Cretaceous and Pleistocene. The Commission has established an Anthropocene Working Group to write a report on whether the new epoch should be added officially to the scale. It is expected to make a decision in the next 3-4 years. In a sense, the task of the working group is to predict what geologists will find a million years hence.

What kinds of evidence are being considered that point to the addition of a new epoch in the geological time scale?[4] There are four kinds:

- Evidence of large-scale shifting of sediment across the terrain due to construction, agriculture and irrigation;
- Anticipated sea-level rise due to anthropogenic warming;
- Rapid rates of species extinction and the spread, mainly due to agriculture, of exotic species across the globe; and
- The prevalence around the globe of artificial organic molecules, carbon isotopes from fossil fuel combustion and radionuclides from atomic bomb tests.

Implications

What are the implications of all this? The historian Dipesh Chakrabarty has pointed out that the distinction we have always drawn between *natural* history – slow processes that occur on a scale of millions of years – and *human* history – a series of events that occur on the scale of years, decades and centuries – has now collapsed.[5] With the Anthropocene, humans have become a geological force so that the two kinds of history have converged and it is no longer true that "all history properly so called is the history of human affairs". Our future has become entangled with that of the Earth's geological evolution.

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[4] Zalasiewicz, J, Crutzen, P. and Steffen, W., The Anthropocene, in F M Gradstein et al. (eds), *The Geologic Time Scale*, Elsevier (forthcoming)
Also http://rsta.royalsocietypublishing.org/content/369/1938/1036.full.pdf+html
[5] Dipesh Chakrabarty, 'The climate of history: Four theses', *Critical Inquiry*, 35 (Winter 2009).

What does it mean for humankind to inscribe itself into geological time? If since the dawn of the modern era we have thought of ourselves as creatures of culture what does it mean when culture becomes so potent that it interferes with the great processes of nature that make the planet a dynamic entity?

We have always understood the natural world as a thin layer of living things and the systems that support them (soils, atmosphere, water) spread over a large ball of rock. It is now more accurate to understand nature as a kind of furry skin covering a spherical "beast" slumbering in the sun's warmth. What we have until now understood as nature grew out of the perspective of intelligent fleas living on the skin of the beast, burrowing down a little, disturbing the fur, multiplying and becoming so hyperactive that the beast now has a severe skin condition.

It is not easy to shift our understanding of the Earth from the idea that it is a static ball of rock covered by a thin layer of biological fuzz to a deeper conception of it as a total entity in a constant state of flux, one in which humans have become the dominant process. I asked a number of Earth scientists how best to communicate this idea. Each has a unique way of expressing it.

Former president of the Royal Geological Society, Bryan Lovell, replied: "The short answer is plate tectonics … the theory that links earthquakes, volcanoes and drifting continents. … all you really need to know is that there are marine fossils at the top of Everest, scraped off the floor of an ancient ocean and pushed up into the sky as India collided with Asia."

Geologist and chair of the Anthropocene Working Group, Jan Zalasiewicz, put it this way: "the Earth seems to be less one planet, rather a number of different Earths that have succeeded each other in time, each with very different chemical, physical and biological states". An Earth without life would "be oxygen-free, grey-green at the surface, possess only about half of its current complement of mineral species, and have quite alien cycles of carbon, nitrogen, phosphorus and so on … An inert ball it certainly is not."

Finally, Earth system scientist Will Steffen also had a fascinating take, suggesting I "point to the circulation of the two great fluids, the ocean and the atmosphere. They are always moving and changing, the atmosphere faster than the ocean. Sometimes

their coupling can lead to violent phenomena, like tropical cyclones."

Environmentalism

The arrival of the Anthropocene has some far-reaching implications for environmentalism. Let me begin with an apparently unquestionable claim made in an article in *Salon.com*: "At the heart of modern environmentalism is the idea that the planet must be saved from further damage by humanity."[6]

This statement seems uncontroversial. Yet environmentalism, at least that part of it that stays close to science, is undergoing a radical transformation that renders the statement untrue. This is because the conception of "the planet" on which modern environmentalism was founded has now been turned on its head by Earth system science.

In its early days, the science of ecology showed how easily complex ecosystems could be degraded and species obliterated. In 1962, by observing the damage to humans and nature caused by factories and industrial agriculture, Rachel Carson in *Silent Spring* presented nature as highly vulnerable to destruction by the power of synthetic chemicals.

The early view of nature as fragile, that is, easily disrupted and unable to repair itself, has been tempered somewhat by evidence that many ecosystems are more resilient and can adapt to new circumstances, although it remains true that we appear to be in the middle of the sixth mass extinction. But whether fragile or robust, the Earth has been understood as unresponsive, neutral and essentially benign. This understanding has various expressions, including the notion of living harmoniously with nature, an idea drawn from images of pre-industrial peoples living close to the natural world. "Mother Earth" is nurturing, feminine and easily damaged.

Underlying these conceptions is a view that, while humans can cause a great deal of damage, nature is passive and always our victim. Yet now we see that the planet has been disturbed from its resting state, jolted out of the providential era of climatic stability characteristic of the last 10,000 years, and is now on a new and largely uncontrollable path that is creating conditions dangerous for human life. The Earth is

[6] Michael Lind, Is it time to embrace environmental change?, *Salon.com*, 13 December 2011

now understood as a dynamic system with strong feedback effects that can suddenly shift it to a new state when critical points are crossed.

The new science turns upside down how we think about our relationship to the planet. We must no longer see the Earth as the submissive repository for supplying our resources or taking our wastes, nor as the docile victim of our rapacity or carelessness. The new understanding of the Earth has been expressed vividly and bluntly by palaeoclimatologist Wally Broecker:

> The palaeoclimate record shouts out to us that, far from being self-stabilizing, the Earth's climate system is an ornery beast which overreacts even to small nudges.[7]

When the Earth is understood this way the task of environmentalism can no longer be to save the planet, for the planet we wanted to save has become something else, not the kind of thing that can be "preserved". Our task now is to do what we can to pacify, or at least not aggravate further, something vastly more powerful than we are and whose "psychology" we can barely understand.

If we have wakened the slumbering beast by poking and prodding it, the prudent course is firstly to stop. But we cannot put it back to sleep. There is no return to the peaceful conditions of the Holocene, at least not for thousands of years; but to provoke it further, as we still are, is foolishness on an epic scale.

Yes, the Earth still demands our respect, but it is a respect founded on trepidation rather than love. If we are inclined to think of the planet as Gaia, we would do better to regard it not as the all-loving, all-nurturing Mother Earth of the romantics, but more like the half-crazed, bloodthirsty and vindictive goddess of the original Greek tales.

It's too late to negotiate with the Earth

Some believe we must negotiate a new contract with nature.[8] Under the terms of this *natural contract* humanity would reject mastery "in favour of admiring attention,

[7] W. Broecker, 'Ice cores: Cooling the tropics', *Nature*, 376 (20 July 1995), pp. 212-3
[8] Michel Serres, *The Natural Contract*, University of Michigan Press, Ann Arbor, 1995 [1992]

reciprocity, contemplation, and respect". The contract would grant nature rights and make reparations.

Twenty years ago that kind of thinking seemed to make sense. But today we must ask whether the Earth, roused from its slumber, is in any mood to sign a contract with us. Are we in a position to grant Nature contractual rights? Is Nature keeping a record of our ecological debt? Do we hear the victim of humankind's rapacity plaintively calling to us for more consideration?

Earth system science now teaches us that the planet to which we graciously offer a peace deal – the receptive, predictable object of our exploitation and neglect – existed only in our imaginations. The enlightened among us desire harmony, sustainability and cooperation, but these aspirations clash with the globe scientists now vividly describe using metaphors like "the wakened giant" and "the ornery beast", the planet that is "fighting back" and seeking "revenge", a world of "angry summers" and "death spirals".

So we are in no position to begin signalling our willingness to negotiate a new contract with the Earth. The Earth does not want our love. Instead of talking restitution should we not be preparing for retribution?

Engineering the blue planet

It is often said that the first full image of the "blue planet", taken by the Apollo 17 space mission in December 1972, revealed Earth to be precious, fragile and protected only by a wafer-thin atmospheric layer. It reinforced the imperative for better stewardship of our "only home".

But there was another way of seeing the Earth revealed by those photographs. For some the image showed the Earth as a total object, a knowable system, and validated the instrumentalist belief that the planet is there to be used for our own ends. In this way, the "blue planet" image was not a break from technological thinking but its affirmation. A few years earlier, the theologian Paul Tillich was one of the first to reflect on the spiritual consequences of space exploration:

> One of the results of the flights into space and the possibility of looking down at the earth is a kind of estrangement between man and earth, an 'objectification' of the earth for man … . She becomes a large, material body to be looked at and considered as totally calculable.[9]

In objectifying the planet as a cybernetic system the Apollo 17 photograph legitimized the Earth as a domain of technological manipulation, a domain from which any unknowable and unanalyzable element has been banished. It prompts the idea that the Earth as a whole could be subject to regulation.

If our influence has been so pervasive and powerful that we have shifted the Earth onto a new, unstable and unpredictable trajectory from which there is no going back, then our task is no longer to attempt to return nature to "normal". It is no longer a question of how to minimize our impact so nature can get on with its natural ways, but of how best to manage it. The debate now brewing is whether we see this as an opportunity to mobilize the full power of technology or as calling for a careful, rear-guard operation.

The Promethean plan for ultimate control has been set out explicitly by Brad Allenby, an engineering professor at Arizona State University, in a strategy he calls earth systems engineering and management. He writes:

> Earth systems engineering and management may be defined as the capability to rationally engineer and manage human technology systems and related elements of natural systems in such a way as to provide the *requisite functionality* while facilitating the active management of strongly coupled natural systems.[10]

The training manual phraseology and the implicit confidence that humans can apply engineering principles to regulate a planet, to give it "the requisite functionality", are chilling. The kinds of technological intervention he envisages fall under the rubric of geoengineering, the subject of my most recent book, *Earthmasters: The Dawn of the Age of Clime Engineering* (Yale University Press 2013).

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[9] Paul Tillich, *The Future of Religions*, New York: Harper & Rowe, 1966, p. 45

[10] Brad Allenby, 'Earth system engineering and management', IEEE Technology and Society Magazine (Institute of Electrical and Electronics Engineers) (Winter 2000/2001), pp. 10–24

Geoengineering is the deliberate, large-scale intervention in the climate system designed to counter global warming or offset some of its effects. While some proposed schemes are modest and relatively benign, the more ambitious ones would see humanity mobilizing its technological power to seize control of the climate system, and because the climate system cannot be separated from the rest of the Earth system that means controlling the planet, probably in perpetuity.

While some proposals, such as launching a cloud of mirrors into space to deflect some of the Sun's heat, sound like science fiction, the more serious schemes require no great technical feats. Two or three leading ones rely on technology readily available and could be deployed within months. They include the geoengineering schemes known as ocean iron fertilization and sulphate aerosol spraying, each of which now has a scientific-commercial constituency.

Ocean iron fertilization entails spreading iron slurry across the seas to persuade them to soak up more carbon dioxide. Carried out on the scale required to counter some global warming it would change the chemical composition and biological functioning of the world's oceans. Marine ecosystems would of course be affected.

But the headline geoengineering scheme, the one whose speedy deployment is already being advocated, is known as sulphate aerosol spraying. It would work by enveloping the Earth with a layer of sulphate particles, probably sprayed into the upper atmosphere by a fleet of specially adapted aircraft, which would reduce the amount of sunlight reaching the Earth's surface. Reducing solar radiation would cool the planet. It is akin to installing a global thermostat. One group of scientists is urging deployment of sulphate aerosol spraying over the melting Arctic now. A Californian company named Intellectual Ventures, backed by Bill Gates, has taken out a patent on a device it calls the "StratoShield", which would serve as such a thermostat.

Technologies of planetary control immediately raise the question of who would be pulling the levers. Generals have always dreamed of controlling the weather. In the Cold War both sides invested in research to manipulate the weather for military purposes. The military is keeping a close watch on geoengineering because of its far-reaching strategic implications. The CIA is undertaking an evaluation.

Dreams of escape

Geoengineering is often referred to as Plan B, one we should be ready to deploy because Plan A, cutting global greenhouse gas emissions, seems unlikely to be implemented in time. Others are now working on what might be called Plan C. It was announced in *The Times* last month (28 April 2014):

> British scientists and architects are working on plans for a "living spaceship" like an interstellar Noah's Ark that will launch in 100 years' time to carry humans away from a dying Earth.[11]

It is known as Project Persephone, which is curious as Persephone in Greek mythology was the queen of the dead. Its website announces that the goal is to build "prototype exovivaria – closed ecosystems inside satellites, to be maintained from Earth telebotically, and democratically governed by a global community."[12] NASA and DARPA, the US Defense Department's advanced technologies agency, are also developing a "worldship" designed to take a multi-generational community of humans beyond the solar system.

Paul Tillich commented on the intoxicating appeal space travel holds for certain kinds of people. Those first space flights became symbols of a new ideal of human existence, "the image of the man who looks down at the earth, not from heaven, but from a cosmic sphere above the earth".[13] A more common reaction to Project Persephone is summed up by a reader of the *Daily Mail*: "Only the 'elite' will go. The rest of us will be left to die."

Perhaps being left to die on the home planet would be a more welcome fate. Imagine being trapped on this "exovivarium", a self-contained world in which exported nature becomes a tool for human survival, a world where there is no night and day, no seasons, no mountains, streams or oceans, no worms or wedge-tailed eagles, no ice, no storms, no winds, no sky, no Sun, a closed world whose occupants would work to keep alive by simulation the archetypal habits of life on Earth. What kind of person imagines him or herself living in such a world? What kind of being, after some

[11] Kaya Burgess, "Space ark will save man from a dying planet", *The Times*, 28 April 2014
[12] http://projectpersephone.org/pmwiki/pmwiki.php
[13] Paul Tillich, *The Future of Religions*, New York: Harper & Rowe, 1966, p. 43

decades, would such a post-terrestrial realm create? What kind of children would be bred there?

According to Project Persephone's sociologist, Steve Fuller: "If the Earth ends up a no-go zone for human beings [that's what he said, a no-go zone for human beings] due to climate change or nuclear or biological warfare, we have to preserve human civilisation."

Why would we have to preserve human civilisation? What is the value of a civilisation if not to raise human beings to a higher level of intellectual sophistication and moral responsibility? What is a civilisation worth if it cannot protect the natural conditions that gave birth to it? Those who fly off leaving behind a ruined Earth would carry into space a fallen civilisation. As the Earth receded into the all-consuming blackness those who looked back on it would be the beings that had shirked their most primordial responsibility, beings corroded by nostalgia and survivor guilt.

He's now mostly forgotten, but in the 1950s and 1960s the Swedish poet Harry Martinson was famous for his haunting epic poem *Aniara*, which told the story of a spaceship carrying a community of several thousand humans out into space escaping an Earth devastated by nuclear conflagration. At the end of the epic the spaceship's controller laments the failure to create a new Eden:

> I had meant to make them an Edenic place,
> but since we left the one we had destroyed
> our only home became the night of space
> where no god heard us in the endless void.

So from the cruel fantasy of Plan C we are obliged to return to Plan A, and do all we can to slow the geological clock. If on this Earthen beast provoked a return to the halcyon days of the Holocene is no longer possible, at least we can resolve to calm the Anthropocene's agitations and so make this new and unwanted geological epoch one in which humans can survive.