The Anthropogenic Global Warming Theory and the Hundred Million Year Outlook for Homo Sapiens

A Review of Jan Zalasiewicz, *The Earth After Us*

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Jan Zalasiewicz is a geologist at the University of Leicester. I have been trying to avoid reading his book *The Earth After Us: What Legacy Will Humans Leave in the Rocks?* (OUP, 2008), because I could tell from the title alone that it would wind me up. Now that I have read it, I find I was not mistaken.

Zalasiewicz's intention, stated in his opening chapter, is to offer a geologist's perspective on present-day human society. This is achieved by imagining that, 100 million years in the future, our planet is visited by extraterrestrial aliens, geologists like himself, who are faced with the puzzle of working out who we were from the 100-million-year-old fossils which is all that our cities, our machines and our bones have left in the rocks.

"The arguments put forward", he states disingenuously, "will not be affected by whether we become extinct over such a timescale [...] No special pleading need be involved; one can simply apply normal geological principles to studying the preservation potential of humans and their handiwork. The estimates used will stay sober and conservative. Where different trajectories or options are possible, these will be spelled out" (p.4).

This sounds very fair and even-handed. So what are the "different trajectories" possible for the human species over the next 100 million years? Clearly there are in principle three broad options (which may be combined to create more complex histories):

1. Our current civilisation collapses very soon, and a few thousand to a few million years later our species dies out completely;

2. Our current civilisation collapses very soon, a few thousand to a few million years later our species dies out – but not before it has produced one or more daughter species, one of which may or may not reinvent civilisation for itself, and one or more of which may or may not have living descendants when the aliens arrive;

3. Our current civilisation continues on its trajectory of rapid growth, leading to interplanetary and ultimately interstellar colonisation, and over a few thousand years our species transforms itself through genetic, information and other technologies into a long-lived and widely dispersed family of hybrid bio-technological successor species.

(A fourth conceivable option, that of civilisation being maintained at close to its current level on Earth over geological timespans, without either developing and spreading further, or going into terminal decline, is in my view quite unrealistic. Our current civilisation does not represent a long-term sustainable state, but rather a period of rapid transition between two such states – a village-scale low-tech one and a galactic scale high-tech one.)

So how does Zalasiewicz "spell out" these options? He does not.

The Earth After Us is based entirely upon option (1): we become extinct, and soon, and nothing is left of us but fossil traces in the rocks. Option (2) is not mentioned at all; option (3) earns a single throwaway line (p.3) and is afterwards not referred to again. It is apparently acceptable for the aliens to have an advanced starfaring civilisation, but not for us, though no reason is offered for this view.

Incidentally, Zalasiewicz's aliens seem to be constantly changing their identity. Starting out as "extraterrestrial explorers" (p.4), they become in turn "interplanetary" (p.13), "interstellar" (p.35), and finally "intergalactic" (p.214), growing in stature in the author's mind as the book continues. Humans, on the other hand, receive consistently low esteem (though one has to ask: how did the aliens get to achieve starfaring immortality if they didn't pass through an intermediate humanlike stage?).

But in a way, isn't sticking to option (1) reasonable enough on its own terms? Zalasiewicz wants to read us a lecture in geology, focusing on chemistry and stratigraphy, mechanisms of fossilisation and technologies of forensic examination of the rocks. Most of the book is of this innocuous nature. His explorations of how humans and their artifacts might fare when subject to these geological processes is simply a didactic device, a way to add interest to a subject steeped in complex technicalities. He is not *really* proposing as his main theme that there will be nothing left of us in 100 million years time?

Or is he? For not only have we left behind our fossil remains, but we are also responsible for major global climate changes which he proposes his alien visitors will also be able to read in the rocks. Inspired by the climatic turbulence in prospect, his concluding chapter veers away from science to become a sermon: we should adopt "softer energy paths" (he does not explain what these are, but the reader is clearly being invited to think more of windmills than of nuclear fission or fusion). We must re-forest the world and find "contentment without the compulsive overuse of resources". The most important thing, in this Reverend Father's view, is "curbing population growth". We must reduce the inequalities between the rich and the poor, dictates the Comrade

General Secretary, and take steps towards "encouraging a common humanity" (p.239-40).

He invokes the aliens in his support: "The current inequalities in wealth [...] may seem to any visiting alien explorer to be the stuff of science fiction" (p.240). So the laws of economics are different on different planets? Or have the aliens developed a utopian socialist society (like that of the Soviet Union, perhaps)? Unfortunately, further details of alien economics are not divulged.

Geology has been left far behind: a human-induced mass extinction of other species "would be a cosmic tragedy, one in which the injuries sustained would not heal for millions of years", which "we should strive to prevent, while we are still able to" (p.240) – in other words, the injuries would heal in a geological tick of the clock to someone versed in hundred-million to billion-year timespans, just as have the injuries of several past mass extinctions.

And what of the "cosmic tragedy" when the Sun heats up enough to wipe out all life on Earth in perhaps a billion years time? Would it not be a far greater tragedy if a high-tech civilisation had meanwhile failed to evolve to the point where it could make Earth's heritage secure from that ultimate disaster, a mortal injury from which Earth could never recover? Our author is indeed aware of this "astrophysical inevitability" (p.8-9) but has no message on this point to deliver – perhaps because it would sit uneasily with his moral strictures on contentment and reducing consumption.

Zalasiewicz seems to take a dim view of the species to which he belongs. A possible reason for this is given on p.103: "There is nothing quite so depressing to a biostratigrapher as a successful fossil that wholly overstays its welcome, and goes on and on." No matter that "conserving living organisms is far more important than conserving fossils" (p.240) – for how else can one explain the view that "our true potential for immortality", "our ultimate legacy" and the "acid test of our ultimate influence, our final footprint on the planet" consist in "the extent to which the human race and its actions are likely to be preserved within geological strata, and thus transported into the far future" (p.3)?

But wait a minute: isn't there another way for us to reach into the far future? Isn't Zalasiewicz himself the product of 100-million-year-old mammals which engendered a line of descent that has continued unbroken, for tens of millions of generations, down the past 100 million years? Apparently not. When humans become extinct, there can be nothing left of us but the silent witness of the rocks. The geologist's attempt to "offer a useful perspective on the current effects of human activity on Earth" (p.5) is therefore missing a major part of what that perspective should contain: our potential living heritage.

Moving on to consider human activities brings us into the turbid realms of climate change and anthropogenic global warming. "Here we tread on speculative ground", writes Zalasiewicz, and how right he is! “But let us plough on, and approach the tender shoots of climate theory with the hobnail boots of blunt enquiry” (p.64).

From a geologist’s perspective, we are given to understand, the current ice age period is abnormally cold. For more than half of the time prior to that the global climate has been much warmer, with little if any permanent polar ice.

But our current situation in the Quaternary Ice Age, now some 2.5 million years old (covering the Pleistocene and Holocene epochs), is one in which we experience repeated long ice ages interspersed with shorter interglacial warm periods. The Croll-Milankovitch mechanism of cyclical variations in Earth’s orbital eccentricity and axial tilt, modulated further by its axial precession, is believed to be secure as the driver of the coming and going of these glacial and interglacial periods. The astronomical periodicities are clearly stamped into sediments recovered from the ocean bottom. But the three cycles are independent and do not form an exactly repeating pattern, “not so much a metronome as an inventive jazz drummer”. Thus the length of one interglacial is no guide to the duration of the next.

Our own interglacial has lasted 10,000 years so far, the three previous ones came to an end after a little over 7,000 years each, the one before that endured for all of 30,000 years (p.78). That longer interglacial “seems to be” the nearest astronomical equivalent to our present situation, which therefore “might” be naturally programmed to last another 20,000 years into the future, during which it might become warm enough to melt enough ice to raise sea levels by another 20 metres, as happened on that earlier occasion, half a million years ago.

Or it might not. The science is simply too tentative to make any reliable predictions (p.73-74). Which of the three mutually interfering astronomical cycles has the clearest effect on the climate is not yet understood: the 100,000-year orbital eccentricity cycle should at present have only a subdued effect, according to the astronomical model, yet it is dominant. Cold and warm periods should arrive at the same rate, according to the model, yet the field data by contrast show abrupt warmings and slow coolings. Short-term temperature changes on a millennial timescale are superimposed on the longer-term pattern; Zalasiewicz regards them as remaining mysterious. (A view which is gathering support is that the millennial variations are due to the solar magnetic cycle, which is known to be correlated with the Little Ice Age of recent centuries, combined with the irreducibly chaotic behaviour of the complex climate system.)

The natural background climate change which the reader is offered is therefore an intensification of the warmth of the current interglacial for the next 20,000 years. Onto this picture must now be superimposed the effect of industrial carbon dioxide emissions (in addition to natural millennial-scale fluctuations), and this is thought to be comparable with a natural greenhouse gas release (carbon dioxide and/or methane) 55 million years ago, in the early Eocene epoch, which caused an already warm world with little polar ice to warm rapidly by a further 5 to 10 degrees Centigrade (p.79-80).

Zalasiewicz poses the question as to whether the human effect will cause only a temporary temperature spike (over several tens of thousands of years), after which the astronomically driven sequence of ice ages of the Pleistocene epoch will resume, or whether we are "dismantling the entire mechanism of the Ice Ages, and plunging ourselves back into the hot climate enjoyed by the dinosaurs for tens of millions of years" (p.80; p.154-157).

Wisely, no doubt, Zalasiewicz refrains from carrying his speculations on the longer-term effects of anthropogenic carbon dioxide any further. He moves discreetly on to his main professional interest with a discussion of the mechanisms of flooding of coastal cities such as London and Amsterdam: if the flooding is slow, then breakers will pound the abandoned cities to pieces, but if they are submerged quickly, then the cities will silt up and become prime candidates for fossilisation and ultimate rediscovery in the rocks of a 100-million-year future age (p.81-85).

Zalasiewicz's perspective on anthropogenic climate change – arguing from geological precedent rather than numerical computer simulations (p.150) – is thus clear enough, though it remains speculative and open to challenge. Doug Hoffman has recently written an article focusing on a late Eocene warming event, at 35 million years ago, which points out that ocean circulation was different then, as geologists are well aware. Because South America, Africa, India and Australia (the major fragments, together with Antarctica, of the breakup of the Gondwana supercontinent) were then all well to the south of their modern locations, equatorial currents which today are blocked were then possible, while the circumpolar Antarctic current had not yet started. Since it is clearly oceanic circulation that redistributes most of the world's heat energy, direct comparisons between the Eocene and the present are misleading, Hoffman argues. Furthermore, atmospheric carbon dioxide levels were generally higher in that epoch, again rendering the comparison with the present moot.

Meanwhile, Hoffman, co-author of a book on climate change (*The Resilient Earth*, BookSurge Publishing, 2008), is at least in agreement in this posting that the current interglacial is likely to be a long-lived one: the next major ice age is still thousands of years in the future.

So even when he is on his home ground as a professional geologist, Zalasiewicz's hobnail-booted conclusions are open to question. But when he speculates about the human future – speculations driven by his geologist's desire to get us out of the way as quickly as possible so that our fossil remains provide a useful time marker in the rocks – he needs to be taken with more than a pinch of rock salt.

"Let us say civilisation survives until it uses up most of its oil and coal reserves", he suggests (p.148); "Give us this century and we will do for the oil, and make a serious dent in the coal" (this was written before the recent announcements concerning large-scale shale gas deposits). He is clearly correct that political and economic forces make continued industrial reliance on fossil fuel consumption a virtual certainty. Thus in a century's time the atmospheric carbon dioxide level will have risen to double its present-day value, causing in his view global warming of around four degrees – “there are geological precedents for that” (p.149).

Zalasiewicz then asks how much ice will melt, and is unable to answer. “We do not know. There are too many feedback loops to predict anything with certainty. It *might* be that the world’s ice caps will grow, and hence sea level will actually fall” (p.149). But “something might just go horribly wrong”. The ice sheets may behave, he speculates, in a non-linear fashion, showing at first little response to a gradual warming, and then crossing an unpredictable threshold of stability and collapsing “over an interval which may be as short as a few decades” (p.149-50).

A reasonable assumption, he judges, is “a sea level rise of, say, 20 metres, a few centuries hence”. This would be “the small change of geological history”, roughly giving us the Pliocene sea level of three million years ago, before the start of the ice ages (p.150).

“For human society”, as he dryly comments, “there would be consequences” (p.150). So how might our civilisation react? What new energy technologies might we introduce as fossil fuels run low and demand continues to rise, and how might our inevitable abandonment of coastal cities and river deltas play out alongside colonisation of the warming continental sub-arctic landmasses of Canada and Siberia?

Zalasiewicz has nothing to say on either count. On the contrary, his implicit judgement on the human species is contained in the question asked by his far future alien explorers: “did it combine high intelligence with breathtaking stupidity in equal measure: to be able to dominate the environment on the one hand and create a technologically sophisticated empire, but simultaneously to dismantle the systems that kept the Earth’s surface stable and habitable?” (p.217). The reader is invited to respond: yes, it did!

But just look at the presuppositions implicit in this judgement. Human activity is making our environment unstable? – yet he has only proposed that industrial emissions will trigger changes which are already encountered in the geological record: the environment is naturally unstable. We may be speeding up those changes, if he is correct, but they will still take “a few decades” to unfold, giving us time to react. Are we making the globe uninhabitable? – yet our species has already endured the ebb and flow of major ice ages with similar temperature swings, and while some areas of a warming world become less habitable, others will naturally become more so. And the worst which he imagines us doing is to return the climate to the hothouse levels which prevailed all through the 185 million years of the Mesozoic era, in which the dinosaurs somehow seem to have flourished in spite of the heat.

But the worst presumption here is the popular fallacy that our civilisation has already reached its final form and has no power to change itself further. In reality the industrial revolution is still in full swing, and the technological, economic and political shape of our society even a single century hence can only be a matter of conjecture. We are surely on solid ground if we assume that the global society of 2111 AD will be as strange to us now as that of 2011 would have seemed in 1911.

What is certain is that large-scale, sustainable and low-pollution energy sources do exist, in the shape of shale gas and nuclear fission for the short term (a few centuries), bridging us over to nuclear fusion and space solar power for the long term. The latter energy sources require some further development, but are clearly capable of powering industrial societies over entire geological epochs. These facts makes nonsense of the bland assumption, which Zalasiewicz makes no attempt to justify, that when fossil fuels run out, that will be the end of civilisation (p.148).

Look again at the mechanisation of agriculture, its increasing control at a genetic level: is food production as dependent upon the naturally fertile river deltas as it used to be? Clearly not. Certainly poorer regions stand to suffer disproportionately if Zalasiewicz's 20-metre sea level rise becomes reality, but will those regions still be as poor and have as few options as they do today in a century's time? Again, how much of our civilisation might by then be based in space, and how sustainable might that outpost of humanity be?

As Benny Peiser has argued in an essay on the Global Warming Policy Foundation website: "environmental determinism is the latest fad in explaining past societal evolution and civilisation collapse." But today: "we have the technological capacity to deal with climatic changes, even with events that may have been catastrophic in the past."

It is this easy populist equation of anthropogenic climate change (of unknown dimensions) with the inevitable decline and fall of the human empire and ultimate extinction of the species which I wish to protest against. It is the meticulous cataloguing of all our evils – "Carbon emissions, extinctions, habitat loss, sea level, and human population are all rising, and if they continue to rise for more than a generation, then prospects will be bleak indeed" (p.239) – while totally ignoring our creative side, expressed most obviously in our potential to spread life out into space, thus preserving the heritage of terrestrial life and civilisation indefinitely, far beyond even the death of the Sun.

Obviously, *Homo sapiens* will one day become extinct, and long before the 100-million-year future envisaged in Zalasiewicz's book. That is not the point at issue. The question is: will we leave post-human descendants, and if so what will they be like?

Even more to the point, the question is: are science, technology and industrial power merely a peculiar characteristic of our species, like say honey is characteristic of bees or an ornate tail characteristic of peacocks? Or do they represent a new departure in evolution which opens up large new possibilities of ecological growth and spatial expansion, on a parallel with the invention of the eucaryotic cell or the Cambrian explosion of the multicellular animal?

Clearly they are the latter, for the following reason. Almost all the matter and energy of the Galaxy which could be used to make and sustain living creatures, in the planetary systems of countless main-sequence stars, is not in fact so used, because it is only accessible to and digestible by a technological species. Our own Solar System illustrates this fact very clearly, and although our knowledge of other planetary systems is still rudimentary, it is already clear that earthlike conditions are very much an astronomical rarity.

Industrial civilisation is therefore an evolutionary departure capable of vastly expanding both the diversity and the ecological range of life. The greatest cosmic tragedy of all would be the failure of such a civilisation to survive for long enough to begin to spread out into space, creating a sufficient variety of self-sustaining colonies to guarantee its long-term survival.

Yes, certainly the process of evolving such a civilisation is a painful one. There is no master plan, no divine guidance, and every step forward can only be made by trial and error. Nobody controls our growing civilisation, nobody can legislate away the cutting-down of forests by people who need the land or disband the armies which march to the tunes of ingrained fear and hatred. Nobody can close down the world's fossil fuel power stations because they are emitting too much carbon dioxide into the air, which is just as well because nobody really knows what the cost/benefit ratio of those power stations will be in the longer term.

Suppose that the industrial revolution results in the extinction of half the species now alive on Earth, and in the process spreads human civilisation far out into space, where our descendants create a million different habitats, in each of which thousands of new species are raised for our descendants' pleasure and profit? Suppose that, 100 million years in the future, 1% of all species live on the planetary surface on which they have evolved, and the remaining 99% live in artificial space colonies created and maintained by industrial societies, some descended from terrestrial humanity, some from alien civilisations which originated around other stars?

Yet that is the prospect which is inevitably suggested to us by the distribution of planetary matter between earthlike worlds and lifeless but usable asteroidal rubble bathed in sunlight, and by the human propensity for industrialising and mechanising its living space, food supply, transport and so on. Walk into any indoor shopping mall and ask yourself: are you on planet Earth, or Mars, or in some future artificial space colony? Apart from the Earth-level gravity, you would hardly know, and even that can be recreated in an O'Neill space colony.

Many people would dismiss the idea as fantasy – after all, if new evolutionary departures only occur once every few billion years, how improbable it would be that one could be happening right now! So let us here reiterate the fundamentals of the human situation in the astronomical universe:

- Almost all the matter and energy of the universe is not at present being used by living creatures (astronomers would see a clear infrared excess if it were);
- The fraction of that matter and energy which could be so used is vastly greater than that available on the surfaces of earthlike planets;
- But that matter and energy are only accessible to and usable by a technological form of life;
- Our own civilisation shows every sign of being roughly halfway through an industrial revolution whose current trends point us towards the capabilities required by a space-based high-tech civilisation;
- Given the demonstrated propensity of life on Earth to develop new forms which take advantage of opportunities to create and occupy new ecological niches, it is entirely reasonable to expect that over the future lifetime of the universe a technological form of life will indeed evolve from its planetary origin and will spread on an astronomical scale;
- But the process of technological development is fraught with risk and blind alleys, and is not controlled by any superior intelligence – in other words, it is an evolutionary process – and one must therefore also expect that many of the species across the universe which start out on this developmental path will fall by the wayside before one succeeds in making the transition to a space-based technological life-form.

Yes, maybe civilisation on Earth will one day fall, and maybe the city builders will become extinct after, say, a mere one million years, giving terrestrial humanity a layer about one metre thick in some Grand Canyon of the future (p.2). Maybe in 100 million years time Earth will indeed be visited by aliens, who know nothing of its history and have to puzzle out the record of the rocks by forensic science alone.

But one important possibility is that those aliens will be our own remote descendants – natives of a star system colonised long ago by starships from the Solar System, who over the passage of the eons have forgotten which star of the 400 billion or so in our Galaxy was the star which gave their species birth, just as we now have forgotten precisely which patch of African savannah was home to our Mitochondrial

Eve, or to the tribes which left the mother continent 80,000 years ago on an expedition which they could not have known would result in their spreading worldwide.

My own prediction is that, 100 million years in the future, only specialists in a remote epoch will have any inkling that life now spread around a billion planetary systems originated on a particular planet orbiting a yellow Sun in the most clement zone of the Galaxy. And most of our descendants, despite genetic and technological enhancements we can yet hardly conceive of, will not even be able to see that Sun through a telescope.

But at the very least, such a prospect must in any view of the human future be given equal weight with the hypothesis that we are about to make ourselves extinct, if not through climate change, then “by any combination of plague, war, and famine” (p.4). On that elementary consideration I must insist.