IS EARTH SYSTEM MANAGEMENT POSSIBLE? ALTERNATIVES?

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Abstract

Reviewing earth system science, philosophy of science and systems theory suggests that predict and control management of the earth system is not currently possible, nor are there reasons to believe that it will be possible. This is more significant given tipping points and thousands of years of inertia in the earth system. Tipping points in natural and artificial systems that regularly lead to abrupt change including catastrophic failure – if not cataclysm – are illustrated with 'icons'. One major 'alternative' to management – stewardship – will be discussed to illustrate what form alternatives might take.

Keywords: Management, Stewardship, Epistemology, Prediction, Earthsystemology

1. Introduction

This paper demonstrates earth system management is not possible and outlines what one alternative – stewardship - might mean. My other paper in this conference discusses how this might be implemented in more detail; in particular, by bringing democratically significant other ethical perspectives to economics to bear on policy by means of participatory policy processes. This is one of the first fruits of a new transdisciplinary field earthsystemology, which adds greater social science and philosophical sophistication to current earth system science.

2. Earth System Science

2.1. Climate Science

Is an assumption that humans can predict the climate system robust for policy purposes? A brief review of climate science will be useful here. The 2001 IPCC reports are an obvious starting point:

> … with a rapidly changing external forcing, the non-linear climate system may experience as yet <u>unenvisionable, unexpected</u>, rapid change
>
> (IPCCWG1, 2001, p. 96 emphasis added)

It should be noted that in IPCC terminology 'external forcing' includes industrial activity. By their 2007 report the IPCC working group one feel the need to address 'Frequently Asked Question 10.2 How Likely are Major or Abrupt Climate Changes, such as Loss of Ice Sheets or Changes in Global Ocean Circulation?' Their answer can be summarised as 'not very likely, we cannot dismiss the possibility but we do not really know'. Given the difficulties in prediction highlighted in this paper and indicated in the detail of their reasoning the tension between 'not very likely' and 'we don't really know' is significant. While it was useful to summarise the research that has been complete since 2001 it would perhaps have been more appropriate for policy-making for the IPCC to emphasise 'we cannot dismiss the possibility but we do not really know' more. The IPCC admit deep epistemological issues with climate science:

> The evaluation of uncertainty and the necessary precaution is plagued with complex pitfalls. These include the global scale, long time lags between forcing and response, the impossibility to test experimentally before the facts arise, and the low frequency variability with the periods involved being longer than the length of most records
>
> (IPCCWG3, 2001, p. 656)

The inertia implied in 'long time lags' may be hundreds of years (IPCCWG1, p. 558) for some components of the climate system and conceivably thousands of years (IPCCSR, 2001, pp. 16-21) this suggests that predictive efforts will need to be robust for these lengths of time for predictive management of the climate (and earth) systems to be effective. The IPCCs evaluation of current limitation in human theories of knowledge is:

> Some of these uncertainty aspects may be <u>irreducible in principle</u>, and hence decision makers will have to continue to take action under significant uncertainty, so the problem of climate change evolves as a subject of risk management in which strategies are formulated as new knowledge arises

(IPCCWG3, 2001, p. 656 emphasis added)

Note the strong assumption of management as the correct response to uncertainty by IPCC. The potential consequences of climate change is illustrated by:

> Finally, a series of potential large-scale geophysical transformations … have been identified and examined more closely in recent years. These imply thresholds that humanity might decide not to cross because the potential impacts or even the associated risks are considered to be unacceptably high. <u>Little is know about these thresholds today</u>

(IPCCWG3, 2001, p. 673 emphasis added)

It is significant that the IPCC has still not made it clear to the general public what these 'large-scale geophysical transformations' or tipping points might be and that 'Little is know about these thresholds today' so that 'humanity might decided [to try] not to cross' them.

IPCCWG2 (2001, p. 129) appear to assume that the assessment of the 'low probability [of] … the occurrence of extreme climate outcomes such as a "runaway greenhouse effect"' is known in an objective sense from 'subjective probabilities' from 'experts'. This may be the best process humans have for making this sort of assessment, but it is hardly 'objective science' (cf. the motto of The Royal Society – 'On the words of no one') and appears to take no assessment of factors that may affect the judgement of these experts, such as:

- Commitment to: particular ontological assumptions, scientific paradigms, scientific methods, ethical frameworks, economic and political arrangements.
- Supra-rational beliefs about the robustness or otherwise of the earth system, and the basis of those beliefs.
- Level of expertise in the philosophy of science, in particular any current limitations of science.

Shackley and Wynne (1995) suggests a conclusion of low probability of extreme events might be as much conditioned by the answers policy-makers want as what science on its own can justify. The reason that policy-makers might not want to hear about unpredictable events could be because their standard tools, particularly economic cost benefit analysis, find it difficult to respond to this possibility.

All this gives an indication of the nature of current climate science and our current lack of robust predictive abilities. Authors who appear wedded primarily to considering consequences in the rest of their article, still suggest the following policy implications:

> Hence, it appears that one should not rely on prediction as the primary policy approach to assess the potential impact of future regional and global climate change.

(Rial et al, 2004, p. 31)

2.2. Biodiversity, Toxicology and GM

Similar epistemological issues affect a range environmental questions that are bound up with complex systems. To give three examples let us briefly consider biodiversity, toxicology and genetic modification.

One aspect of the science of biodiversity that displays the difficulty in managing biodiversity by prediction and control is keystone species. Reasons that can be identified in Power et al. (1996) include firstly difficulty of doing experiments that adequately isolate causal factors in complex ecosystems. Secondly, difficulty of knowing where to draw theoretical boundaries between the area affected by the keystone species interaction and other areas where the interaction is of a different nature. Thirdly, difficulty of understanding the long-term interactions within the ecosystem being studied before and after any study. This suggests that base data are difficult to obtain. This last difficulty is perhaps particularly acute in the:

> … increasing number of large-scale "natural experiments" [that] are occurring through massive human habitat alteration and associated bio-diversity loss

(Power et al., 1996, Unpaginated)

In their review of research into keystone species Power et al. (1996) note the widespread applicability of the keystone species concept and the variety of ways that those species can cause non-linear changes in ecosystems.

> … keystone species, as we have defined them, have been demonstrated or suggested to occur in all of the world's major ecosystems … keystone species can exert effects, not only through the commonly known mechanism of consumption, but also through such interactions and processes as competition, mutualism, dispersal, pollination, disease, and by modifying habitats and abiotic factors.

(Power et al., 1996, Unpaginated)

They also note that there are not yet successful ways of predicting which species are keystone species (Power et al., 1996). When reflecting on this they suggest, with particular regard to conservation management:

> … the keystone concept points to the need for a cautious management strategy that takes into account potential surprises from small interventions or changes
>
> (Power et al., 1996, Unpaginated)

To summarise, Power et al. (1996) suggested that science cannot yet predict which species are keystone species in an ecosystem, where within an ecosystem a species will be keystone, how much disturbance it will take to remove the function of a keystone species from an ecosystem, and what are the important interactions within and between ecosystems that include keystone species. These types of issue cause Ludwig (2001), in considering management of ecosystems, to declare *The Era of Management Is Over*.

Similar and equally difficult questions can be raised around the harm from and toxicity from chemicals. Let us note just two examples. The following quotation gives an indication of the size of the task of understanding the effects of chemicals and indicates how little of the task has been completed, even for one characteristic:

> … about 5 Million different chemical substances are known to exist, and their safety is theoretically under regulatory jurisdiction. Of these, it is pointed out, fewer than 30 have been definitely linked to cancer in humans, 1,500 have been found to be carcinogenic in tests on animals, and about 7,000 have been tested.
>
> (Adams, 1995, 45)

If the above was not enough, there are difficulties in understanding even one effect (Cox and Tait, 1991). A 2003 Royal Commission report raises similar questions leading the chairman to comment:

> Given our understanding of the way chemicals interact with the environment, you could say we are running a gigantic experiment with humans and all other living things as the subject … We think that's unacceptable
>
> (RCEP, 03-02)

This 'experiment' includes low-level long-term effects, including chemicals interacting with each other and interactions with ecological systems. It is not clear that there are any processes, scientific or otherwise, that can make robust assessments of the effects of chemicals in this way.

Similar issues affect current scientific ability to understand the effects of genetic modification on global ecological systems. That is, it is limited by the nature of scientific observation and experimental method. As a research report puts it:

> It is inherently difficult, given the current state of ecological knowledge, to spell out the full sequence of events associated with GMO release.
>
> (Department of the Environment, 1995, 144)

It is not clear that there is any equipment that can be used to observe the effects of human caused genetic modification (or persistent toxic chemicals) throughout the globe.

2.3. Earth Systems Science

Steffen and Tyson (2001) is a clear brief treatment of earth system science, the potential risks of current human behaviour and the implicit policy implications. For example:

> … changes taking place are, in fact, changes in the human-nature relationship. They are recent, they are profound, and many are accelerating. They are cascading through the Earth's environment in ways that are difficult to understand and often impossible to predict. Surprises abound. … these human-driven changes to the global environment … may drive the Earth itself into a different state that may be much less hospitable to humans and other forms of life.
>
> (Steffen and Tyson, 2001, Foreword)

Steffen and Tyson (2001) go on to indicate more specifics, including:

> The human enterprise drives multiple, interacting effects that cascade through the Earth System in complex ways. … The Earth's dynamics are characterised by critical thresholds and abrupt changes. Human activities could inadvertently trigger changes with catastrophic consequences for the Earth System. … the Earth System has recently moved well outside the range of the natural variability exhibited over at least the last half million years. The *nature* of changes now occurring *simultaneously* in the Earth System, their *magnitudes* and *rates of change* are unprecedented.
>
> (Steffen and Tyson, 2001, p. 3, emphasis in original)

This quotation indicates the significance of the multiple stresses that humans are causing to the earth system and its components. They go on to give concrete examples including:

> … palaeo-record shows that … recorded changes were often rapid and of high amplitude; in some cases temperature over large regions changed by up to 10°C in a decade or less.
>
> (Steffen and Tyson, 2001, p. 10)

The last quotation is an example of a tipping point that has been crossed in the past and the potential consequences of current stress. If the above discussion of earth system science is added to the inertia already discussed with regard to climate change then any assumption of predictive management and control of the earth system need to be very robustly justified. Or as Steffen et al (2004) write:

> Systems theory suggests that complex systems can never be managed; they can only be perturbed and the outcomes observed. Furthermore many of these outcomes will be likely unpredictable … This property of complex systems is manifest in the Earth System … Humans … cannot be in a position to manage the Earth System …

(Steffen et al, 2004, 286 see also 295, 297-8)

3. Philosophy of Science and Systems Theory

3.1. Philosophy of Science

Despite the preferences of Francis Bacon and Karl Popper it is not clear that any philosophers of science including the logical positivists, Popper, Kuhn, Lakatos or Feyerabend have suggested ways in which complex systems such as the earth system can be robustly predicted; this is despite making authors such as Gillott and Kumar (1995) uncomfortable, with some good reasons.

3.2. Systems science

Authors such as von Bertalanffy (1971), Laszlo (1972) and Jantsch (1980) discuss systems theory and systems science, with Jantsch (1980) giving a key reason to suggest that prediction of the earth system is not currently possible. Specifically, Jantsch (1980) discusses systems that change state at a specific or ‘critical’ level of disturbance, noting everyday occurrences of this phenomenon. Jantsch does not describe how to find critical thresholds where switches in state will take place, except with laboratory systems where repeatable experiments can be done. This difficulty in finding ‘tipping points’ still appears true for earth system science despite there being at least one journal devoted to ‘Nonlinear Processes in Geophysics’. All this appears to indicate that, at present, there is no robust way of finding all critical thresholds in global and more local ecological systems that appear essential to life, other than at the risk of blowing up the 'laboratory' along with the experimenters.

An example of critical thresholds in relatively simple systems is metal fatigue, where a crack propagates for months or years from a small imperfection, until the material is sufficiently weakened for it to break in fractions of a second. This can ‘take place even though the peak stress is well below the ultimate tensile stress’. Given that metal fatigue was only widely recognised after numerous fatal ‘real world experiments’ and is still an issue that leads to fatalities in industries such as aviation, this suggests that the assumption that humans can spot all thresholds in the earth system in time to stop them being crossed is highly questionable. It is also important to note that many materials, once stressed to a certain level, cannot return to their original state and will break even if the stress on them is reduced. Specifically with regard to earth system science the state of the art in identifying where critical thresholds are can be indicated by:

> There are now methods developed in biophysics that try to anticipate when critical systems thresholds will be crossed by detecting warning signs of the imminent phase transition. The latter approach is particularly relevant to Earth System analysis that attempts to identify the switch and choke points in the planetary machinery that might be inadvertently activated by human activities. In fact, science can even benefit from the existence of strong nonlinearities in the Earth System by devising an inverse sustainability strategy that calculates the critical anthropogenic perturbations to be avoided at all costs.

(Steffen and Tyson, 2001, 25)

However, they do not provide details or references to how calculations of levels of these critical perturbations may be achieved. Kleinen et al (2003) do offer one possible method. This is tested by a ‘simple two-box model of the hemispheric thermohaline circulation’ (Kleinen et al, 2003, 53), but at the current level of development this perhaps suggests that robust process cannot be assumed as much as anything else.

One ‘icon’ of tipping points – metal fatigue – has been indicated; in order to make clear how common rapid change in systems are, it worth naming some more:

- Avalanches
- A high sided vehicle overturning in cross winds or during rapid manoeuvring
- Allergic reactions to nuts or insect stings
- Heart attacks and multiple-organ-failure
- Volcanoes and earthquakes
- Domino effects including Tsunami
- Stock market crashes
- Political revolutions – both violent and peaceful.

4. Is management Possible?

In relevant policy and academic literature the term management is commonly used but typically not defined. In *The Concise Oxford Dictionary* (1995) the most relevant definitions of manage are ‘organize; regulate; be in charge of … gain influence with or maintain control over … take or have charge or control of (an animal or animals …)’. This is the sense most commonly used in earth system science and related literature. It should be clear by now that any assumption of predictive management and control of the earth system needs to be very robustly justified.

Thus predict and control management is currently an unreasonable assumption for ‘planetary management’; it may be more reasonable in the future if there is a revolution in systems theory, but until that time for policy purposes other alternatives should be considered and may legitimately be argued to more rational.

5. Alternatives to management

Stewardship is a term often used in the earth system science and sustainable development literature, if less used than management. Passivity is a one further alternative, which in practice could entail becoming a nomadic fruitarian, voluntary starvation or suicide, which I will assume are not realistic solutions to current anthropogenic earth systems stress.

Let us return to stewardship. The most relevant definition of steward in *The Concise Oxford Dictionary* (1995) is ‘a person employed to manage another’s property’. This points to two differences between management and stewardship that might be relevant to environmental issues, first that stewardship is on be half of others e.g. future generations; second, a related point, that it what is stewarded is not for the steward to do with as they wish. Many sophisticated notions of private property equally call into question whether property can be abused where this harms the common good, but further discussion is beyond the scope of this paper. Where earth systems science literature considers limits to human abilities to predict, the emphasis is on reducing stress to the earth system (broadly stewardship) from humans rather than predicting and controlling the earth system (broadly management).

Attfield (1994, particularly 41-62) is a useful discussion of the notion of stewardship that suggests ‘stewardship’ is less instrumental than ‘management’ and perhaps makes less strong assumptions about abilities to predict. Attfield (1994, particularly 13-62) indicates how the historical notion of stewardship did not assume anthropocentric human interests as always paramount and could underpin a notion of sustainable development. A reasonable broad definition of stewardship would be care on behalf of others. More specifically the notion of stewardship could be to minimise interference (stress) at the global level, but encourage intelligent husbandry at the local level. To give concrete indications; at the global level minimising stress could occur with something akin to ‘The Natural Step’ (Natural Step, 2000), whereas at the local or micro level, global principles such as the natural step could be worked towards with models such as Permaculture (Mollison, 1988). That is, humans can perhaps manage their local productive environment to minimise stress to the earth system.

Barry (1999) explicitly recommends stewardship as the ecological virtue, however his justifications for this are not particularly clear. Nonetheless the logic that Barry (1999, 72) indicates of stewardship, as a balance between overconfidence in human abilities to control nature and paralysis in the face of difficulties in knowing the consequence of human actions, broadly accords with global virtue tradition.

Alexander (2001) a retiring editor of *Environmental Management*, remarks that the founding editor of the journal believed ‘environmental management signified stewardship: not control of nature, … care and respect’ (Alexander, 2001, 701). This suggests potentially important connections between epistemology and ethics. Alexander (2001, 701) goes on to state ‘many environmental problems and solutions have unexpected repercussions’, which is a key possible epistemological reason why prevention of environmental problems is better than cure, and prediction and control is a questionable approach to ‘management’ of ‘the environment’.

There is little in recent issues of the journal to support an assumption that even at a reasonably local level nature can be predicted and controlled for human benefit in a Baconian way. From the viewpoint of this paper, it is unfortunate that these practitioners have not been able to convince governments and key policy makers that the earth system cannot be made to conform to human desires.

When Ludwig (2001), in considering management of ecosystems declares, *The Era of Management Is Over*, primarily for epistemological reasons but he also implies that the ethical assumptions implicit in ‘management’ need to made explicit and debated rather than assumed and imposed by policy makers.

Steffen and Tyson (2001) are earth system scientists who make clear that debate over what form of stewardship or management are required is urgent, even if their use of the terms stewardship and management is a little imprecise:

> Ethics of global stewardship and strategies for Earth System management are urgently needed. The inadvertent anthropogenic transformation of the planetary environment is, in effect, already a form of management, or rather mismanagement. It is not sustainable. Therefore, the *business-as-usual* way of dealing with the Earth has to be replaced – as soon as possible – by deliberate strategies of good management.

(Steffan and Tyson, 2001, 3)

6. Conclusions

This paper has demonstrated that an assumption of predict and control management of the earth system is, currently and for the foreseeable future, deeply problematic and will need to be robustly justified wherever it is made. This paper has demonstrated that there are conceptual and practical alternatives to earth system management. If management can no longer be assumed as the default relationship between nature and human industrialized activity then there is a need for processes by which processes (broadly stewardship or management) are chosen. Much of the inter-governmental sustainable development policy literature suggests more participative processes than managerial/administrative approaches typically used by government. My other paper at this conference will explore reasons for that in more detail and what participative policy processes mean in practice

7 References

- Adams J (1995) *Risk*, London: UCL Press

- Alexander (2001) ‘Farewell Remarks from the Retiring Editor-in-Chief’, *Environmental Management*, Vol 28, No 6, pp 701-2

- Attfield R (1994) *Environmental Philosophy: Principles and Prospects*, Aldershot: Ashgate

- Barry J (1999) *Rethinking Green Politics: Nature, Virtue and Progress*, London: Sage

- Cox S.J and Tait, N.R.S. (1991) *Reliability, Safety and Risk Assessment*, Oxford: Butterworth-Heinemann

- Department of the Environment (1995) *An Evaluation of GENHAZ as a Risk Assessment System for Proposals to Release Genetically Modified Organisms into the Environment*, London: Department of the Environment

- Gillott J and Kumar M (1995) *Science and the retreat from reason*, London: Merlin Press

- IPCCSR (2001) *Climate Change 2001: Synthesis Report*, Cambridge: Cambridge University Press

- IPCCWG1 (2001) *Climate Change 2001: The Scientific Basis*, Cambridge: Cambridge University Press

- IPCCWG2 (2001) *Climate Change 2001: Impacts, Adaptation and Vulnerability*, Cambridge: Cambridge University Press

- IPCCWG3 (2001) *Climate Change 2001: Mitigation*, Cambridge: Cambridge University Press

- Jantsch E (1980) *The Self-Organizing Universe: Scientific and Human Implications of the Emerging Paradigm of Evolution*, Oxford: Pergamon

- Kleinen T, Held H, Petschel-Held G (2003) ‘The potential role of spectral properties in detecting thresholds in the Earth system: application to the thermohaline circulation’, Ocean Dynamics, Vol 53, pp 53–63

- Laszlo E (1972) *Introduction to systems philosophy toward a new paradigm of contemporary thought*, New York: Gordon and Breach

- Ludwig D (2001) ‘The Era of Management Is Over’, *Ecosystems*, Vol 4, No 8, pp 758-64

- Mollison B (1988) *Permaculture: A Designers Manual*, Tyalgum NSW: Tagari Publications

- Natural Step (2000) *The Natural Step Framework Guidebook*, http://www.naturalstep.ca/articles/TNSFrameworkGuidebook.pdf

- Power ME, Tilman D, Estes JA, Menge BA, Bond WJ, Mills LS, Daily G, Castilia JC, Lubchenco J and Paine RT (1996) ‘Challenges in the quest for keystones’, *Bioscience*, Sep96, Vol. 46 Iss 8, p609 12p – Unpaginated when accessed via the Internet

- RCEP (03-02) *Chemicals in Products: Safeguarding the Environment and Human Health Reducing the Risks from Chemicals*, Royal Commission on Environmental Pollution: News Release, http://www.rcep.org.uk/news/03-02.htm

- Rial J, Pielke Sr RA, Beniston M, Claussen M, Canadell J, Cox P, Held H, de Noblet-Ducoudre N, Prinn R, Reynolds J and Salas JD (2004) 'Nonlinearities, feedbacks and critical thresholds within the Earth's climate system', *Climatic Change*, No 65, pp 11-38

- Shackley S and Wynne B (1995) 'Global climate change: the mutual construction of an emergent science-policy domain' *Science and Public Policy*, Vol 22, No 4, pp 218-230

- Steffen W, Sanderson A, Tyson P, Jäger J, Matson P, Moore III B, Oldfield F, Richardson K, Schellnhuber H-J, Turner BL, Wasson R (2004) Global Change and the Earth System: A Planet Under Pressure, Berlin: Springer-Verlag, Executive Summary: http://www.igbp.net/documents/IGBP_ExecSummary.pdf

- Steffen W and Tyson P (eds)(2001) Global Change and the Earth System: A Planet Under Pressure, Stockholm: International Geosphere-Biosphere Programme, http://www.igbp.kva.se//uploads/ESO_IGBP4.pdf

- von Bertalanffy L (1971) *General Systems Theory: Foundations Development Applications*, London: Penguin