MODELLING THE NATURAL CYCLES OF THE HUMAN-EARTH SYSTEM: A HUMAN ECOLOGIST'S PERSPECTIVE [1]

DOUG COCKS

SLIDE: A TALK IN TWO PARTS

My talk is in two parts:

1.Some thoughts on global modelling and global policy options

2. A case study of an under-recognised global policy issue, what I call the Global Overshoot Crisis

Global modelling and global policy options

SLIDE THE POLICY SWAMP

I need to start with a *disclaim*, defined by the OED as the renunciation or disavowal of all part in whatever-it-is. It is decades since I last practised any quantitative modelling of dynamic systems. For some years I enjoyed trying to model the normative planning of farm production systems under climate and market uncertainties. And later I equally enjoyed modelling the physiology of sorghum crops from seed to seed. And I have since worked with many competent modellers and enjoyed quizzing them about the insights emerging from their immersion in their target systems. .

Notwithstanding, I long ago decided that I have neither the mathematical flair nor the passion for data to be a top modeller. Those were the 'push' factors, but the equally important 'pull' factor was that the systems I found myself wanting to understand seemed to be beyond the grasp of modelling as I understood it. And I wanted to make a more direct contribution to various policy debates (e.g. population; natural resource management) and to getting certain important issues onto the policy agenda (e.g. humanity's long-term future). I wanted to brave the policy swamp.

The policy swamp

CSIRO has been wary of its scientists being involved in policy debates since Science Minister Barry Jones went feral after Steve Morton and others produced a very sensible document entitled 'A Policy for the Rangelands.' Jones subscribed to the 'tech-head monkey' view of CSIRO---when politicians need supporting evidence (not disinterested evidence) for a policy, they can open a drawer and out pops a little monkey called CSIRO which babbles away for a moment or two until, mission accomplished, the pollies close the drawer again.

Perhaps I exaggerate, perhaps not. I didn't follow the recent Clive Spash affair when a fully-refereed paper advocating a particular approach to reducing carbon emissions got heavily censored by CSIRO management. However, I did get the impression that

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[1] Paper to ANU-CSIRO Workshop on *Modelling the natural cycles of the human-earth system*, Canberra 7-8 Dec 2010

if the paper had been couched in terms of an exploration of the consequences of alternative policy options, the same points could have been made without creating moral panic. Equally, I suppose, the paper would in all probability have then been ignored.

In one way or another, scientists stand to get burned when they get too close to 'hot button' policy issues. Global-scale modellers are no exception. Those of you involved in climate-change science don't need to be told that. If you do, ask Graeme Pearman. But being attacked and undermined by powerful and unscrupulous vested interests goes back much further of course, starting, I suppose, with the *Limits to Growth* experience. However, I take it that we are not here to discuss how to present and defend global-system science, but how to do it.

SLIDE MY WORLD VIEW

One reason I am at this workshop is that, like others here, I am interested in the dynamics of the whole-Earth system over coming decades, centuries and, perhaps, millennia. I assume that I am like every one else here in having a 'second law' view of the origins and evolution of the human-earth system; and that reality---from the big bang to this workshop---is best understood as an evolving nested hierarchy of dissipative systems in which energy flows and matter cycles.

But I can't quite put my finger on how this world view informs today's workshop or, if it doesn't, why not.

SLIDE WORKSHOP PERSPECTIVE

Anyhow, I am quite happy to accept the starting point we have been given for this workshop. Like others here, I accept that the system outcomes I am interested in are sensitive to economic, social and political processes as well as biological and physical processes; and, most importantly, to the interactions between these components.

The workshop briefing paper enthusiastically calls this perspective 'a new paradigm' but geographers, particularly human geographers, starting with Carl Sauer, have been thinking this way for 100 years, e.g. Jared Diamond is a geographer who has famously argued that gaps in power and technology between human societies originate in environmental differences, which are amplified by various positive feedback loops.[2] I see what is happening in a workshop like this as more an example of E.O. Wilson's *consilience,* meaning a willingness to bring insights from different disciplines to bear on a single problem. .

SLIDE WHAT IS THE QUESTION?

<u>What is the question?</u>

But what exactly is the problem or problems that human-earth-system science is addressing? I don't think it is good enough to say, as the briefing paper does, that the goal is to understand the system. That's what I call a non-operational goal, one that

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[2] Diamond, J. (March 1997). *Guns, Germs, and Steel: The Fates of Human Societies*. W.W. Norton & Company

leaves you open to the jibe that if you don't know where you are going, it doesn't matter which bus you catch.

At very least, you have to say why you want to understand the system, even if it is something as problematic as 'promoting sustainable development.' Even better if you can suggest a criterion for measuring 'successful understanding,' e.g. does 'understanding' mean being able to explain what happened at the focal level of your system in terms of the levels above and below. Perhaps that is where the 'second law' world view comes in.

SLIDE WHAT CAN GLOBAL MODELLING ACHIEVE?

What is possible?

While I am willing to be convinced otherwise, my starting point for thinking about what is currently possible with respect to modelling the Human-Earth System is that because we are talking about a complex, dissipative and evolving system, its behaviour can only be predicted in a very limited way. Its dynamics can be quantitatively modelled or simulated but only in a highly qualified way; for example, with lots of exogenous variables and parameters and one or two sub-systems at a time.

Plenty of whole-earth models have been built, and are still being built I presume. And I have no doubt that they are fun to build and a useful way to explore sub-system interactions. A good example is John Finnigan's recent paper on 'Reconciling Climate Mitigation and Global Change.'[3] Amongst other insights, it picks up a 'mismatch,' Marx would call it a 'contradiction,' between an unstable world trading system and the need for a global food trade if the world's people are to be fed in coming decades. That is a useful insight.

Notwithstanding, in terms of understanding reality I am inclined to categorise most whole-Earth models as 'hypothesis generators,' developed in situations where it is not easy to see how the generated hypotheses can be tested or validated. Also, building big models is expensive and there may be an issue of *opportunity cost* lurking here.

There are other difficulties too (e.g. data availability, endogenising agency) but, despite these, I have no trouble in accepting that human-Earth system modelling has a lot to contribute to the development of what I will call *global policy options.* For example, they can point single-discipline researchers towards knowledge gaps which particularly need filling. They might be able to illuminate leverage points, tipping points, intervention points, boundary conditions, drivers, trajectories etc. But they cannot, on their own, generate global policy options.

SLIDE WHENCE GLOBAL POLICY OPTIONS?

Whence Global Policy Options?

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3 Finnigan, J (2009), The "Diabolical Problem": Reconciling Climate Mitigation and Global Change. Presentation at the CSIRO CSS Global Systems Dynamics Workshop, Lake Crackenback, NSW, 9-12 June 2009.

In the absence of well-established procedures for developing policy responses to global scale 'what-to-do' issues, I have concluded that the best that can be done is to cobble together and select amongst a handful of abductively plausible 'if…then' scenarios or narratives or stories. Choose your own name-tag. An abductively plausible scenario is simply one which is consistent with the known facts and understandings. One asks, 'What are the plausible consequences of some particular intervention'? This is the modest methodology I bring to the second part of my talk today.

SLIDE PART 2 THE GLOBAL OVERSHOOT CRISIS: A CASE STUDY

The Global Overshoot Crisis: A Case Study

This part of my talk is based on a talk I gave recently to the Independent Scholars Association under a title which is the same as a book I am working on, *Global Overshoot: Contemplating the World's Converging Problems* [4] I present it as an example of trying to think constructively about an important global issue without the help of a quantitative modelling scaffold.

SLIDE A CHANGE IN PERSPECTIVE

A change in perspective

Let me start by tracing this project back to an epiphanic change in perspective.

In 2003 I wrote a book called Deep Futures: Our Prospects for Survival.[5] While recognising that this would be a difficult century, it foresaw a long Indian summer for humanity, provided we turned our minds to building a better world.

The present project started from the nagging perception that our prospects could be much worse than I had previously thought and that perhaps we should be seeing our primary task for the foreseeable future as one of defending what we've got, not improving on it; more a case of sandbagging the levees than irrigating the desert. Or, putting it less metaphorically, the need to focus our energies on defensive programs rather than development ventures.

SLIDE HAS AN OVERSHOOT CRISIS BEGUN?

Has an Overshoot Crisis begun?

This is the open-minded question I chose as a starting point for my analysis. The first thing to say about a crisis is that it is not a catastrophe, but a situation of high uncertainty, as when a mother is waiting to see if her child's fever will break.; or the news that an asteroid is approaching the Earth. Crises may or may not turn into catastrophes.

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[4] Talk to Independent Scholars Association of Australia, Canberra, October 2010

[5] Doug Cocks (2006) *Deep Futures: Our prospects for survival,* University of New South Wales Press, Sydney.

I am using the term *overshoot* to describe those situations where one thinks that some process of cumulative change is approaching some limit, a "tipping point," at which some sort of major reorganisation could be triggered. The term has connotations of finding you have gone somewhere you wish you hadn't; and that it might be difficult to return to the status quo ante. Like overshooting your destination and then finding you are about to run out of petrol!

SLIDE WHAT SORT OF CRISIS

What sort of crisis

What sort of crisis was suggesting itself? I have long held that humanity's master goal, its overarching goal, should be what I call *quality survival* by which I mean the achievement of high quality of life (QOL) for most people into the indefinite future. And without going into details I favour a measure based on Abraham Maslow's hierarchy of needs, from the physiological to the spiritual.[6] If I were attempting a quantitative model, I might start with the Human Development Index.[7]

What I could imagine as a plausible scenario was a large and rapid drop in QOL across the world. Remember that a scenario is nothing more than a *plausible future.* I am not making a prediction and I am not the boy crying wolf. I am the boy who says there may be wolves out there in the forest.

SLIDE FOUR OVERSHOOT PROCESSES

Four overshoot processes

To keep discussion manageable, I will restrict myself to identifying just four processes which, if they continue, threaten, singly to some extent, but more so in combination, a large and rapid drop in QOL across the world:

Overpopulation---The world's population is projected to increase by 50% before peaking in 60 or so years.

Global overheating---The world's average temperature has increased by 0.8 degrees in the past century and, if greenhouse gas emissions are not cut more-or-less immediately by 50-60% we might well get another degree of warming in this century. That doesn't sound much but it stands to reshape the geography of the habitable world. Unfortunately we get a third of our emissions and most of our electricity from coal-fired power stations.

Overextraction of resources---The world's transport system runs largely on oil. No really big oil fields have been discovered in recent decades and the phenomenon known as "peak oil" is either here now or on our doorstep. That is production will decline from here on, even if the price rises. Along with oil, phosphatic and

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[6] Abraham Maslow (1968) *Toward a Psychology of Being*, Van Nostrand, New York.
[7] UN Human Development Report 2010 http://hdr.undp.org/en/countries/ (accessed Nov 5 2010)

nitrogenous fertilisers underpin the world's highly productive food system. Phosphate reserves are limited and we are approaching "peak phosphate," although not for some decades probably. The size of the "capital hump" which would have to be clambered over in order to run something like the present global economy on recycled and renewable resources rather than non-renewable resources is vastly under-appreciated.

Overconnectedness or runaway complexification---As world energy use increases, global society is becoming increasingly complex and unpredictable, summed up in the observation that every solution seems to create more problems than it solves. Remember, this is a dissipative system.

Complex systems are characterised by lots of circular causation (virtuous and vicious circles!), long-chain dependencies (for want of a horseshoe nail!) and unforeseen outcomes, e.g. China's one-child policy. When systems reach a certain degree of complexity they have a tendency, depending on their structure, to either freeze up (nothing happens for a long time) or run amok when perturbed, i.e much of their structure disappears. Rational analysis seems to be increasingly inadequate as a way of deciding "what-to-do." about such systems. While complexification is far from being just an economic problem, the economic sphere does provide some splendid examples; with a couple of exceptions, nobody foresaw the Global Financial Crisis.

Before moving on, the point needs to be made that no one has set out to create these threats to global quality of life. They are side-effects, spillovers from self-interested behaviours which most of us have hitherto regarded as quite legitimate, e.g. capitalism's pursuit of profit, a family's wish for a third child..

I might also note that my global problematique is conceptualised in terms of problem trajectories rather than problem cycles.

SLIDE SCENARIO: IMPACTS ON QOL

The stuff of apocalyptic novels

And now for the stuff of apocalyptic novels. It requires only a little imagination and some knowledge of how the contemporary world "reproduces" itself to envisage how, quite plausibly, my four overshoot "juggernauts" might converge and interact to produce a destructuring of world society in ways such as:

The large-scale abandonment of cities bereft of food and power

The large-scale collapse of energy- and import-dependent industries

The extinction or dispersal, on every continent, of numerous regional and national populations and communities

The loss of all sorts of inter-regional and international linkages and joint ventures, including economic, socio-cultural and political

For example, the abandonment of cities and the departure of the experts who live there (e.g. electrical and telecommunications engineers) would quickly bring

organised society, including the economy, to a standstill, starting with import-dependent industries perhaps. Breaks in long supply chains soon ramify.

SLIDE SCENARIO: A DARK AGE FUTURE

A "Dark Age" scenario

Let me evoke a "Dark Age" scenario of how such breakdowns in social organisation might come to impact on the lives of ordinary people:

Irrespective of good intentions, existing problems of war, poverty, injustice, inequity, environmental degradation and sociopathy will grow, not shrink.

Under the combined effects of drought, famine, war, mass migration, poverty, disease, resource exhaustion and economic disruption, the world's population will start falling well before current estimates of a peak in 2070. Many indicators of quality of life, including life expectancy, will slump.

In all countries, especially failed and war-torn states, it will become much harder for most people to meet their everyday needs. Women and children, the old and the sick will be most affected. Jobs will be few. Supply chains for basic commodities (eg food, fuel, medicines) will break. Barter will become normal. Inflation will escalate. Health, education, transport and police services will degrade. Power and water supplies will become unreliable or worse. Roads and other infrastructure will be poorly maintained. Crime and group violence will escalate. Violent protest and looting will be commonplace. Ordinary people will live in fear. Mental illness will be endemic. People will turn to authoritarian regimes for respite.

In brief, cities everywhere will struggle to avoid becoming giant lawless slums. Rural populations will be vulnerable to marauders and incursions from displaced persons. Life will be an exhausting wretched struggle.

Imagine trying to formally model consequences like these.

SLIDE THREE LEGITIMATE RESPONSES TO A DARK AGE SCENARIO

Three legitimate responses to a Dark Age scenario

How might people of different temperaments react to being presented with a scenario like this? Of all the possibilities from fundamentalism to indifference, I have chosen to elaborate on three ways of responding which I regard as legitimate, i.e. as standing to produce useful insights and not to be dismissed out of hand. Expressed in colloquial and in more formal terms, they are:

Empiricism or "Let's wait and see what happens before doing anything."

Interventionism or "Stop fiddling while Rome burns. This catastrophe is inevitable unless we act to stop it right now."

Reconstructionism or 'Rise like a phoenix. This catastrophe is already inevitable. Let's do what we can now to help our descendants rebuild civilisation after the Dark Age passes."

Time allows a few words about the nature and implications of each of these stances:

SLIDE EMPIRICISM

Empiricism

Empiricists believe that one's conclusions should not stray far from the immediate evidence, preferably observational (empirical) evidence. They are first cousins to sceptics who believe that people's assertions need to be justified. They believe in the "precautionary principle" to the extent of not acting before one is confident of the consequences. Their critics see them as the butt of the one-line joke, "Wait a minute, wait a minute, wait a minute …..Bang!" The difficult question of course is "What is the right amount of empiricism and scepticism?" A perennial problem with the Empiricists' stance is that it is readily assumed (hijacked) by vested interests devoted to protecting the status quo, e.g. climate change "deniers."

SLIDE RECONSTRUCTIONISM

Reconstructionism

Reconstructionists are taking the long view and asking what life will be like after the Dark Age and what, if anything, can be done now, before the lights go out, to help the survivors who, plausibly, will be subsistence peasants. Noah and his Ark are their inspiration. It turns out to be surprisingly hard to see how to transmit useful knowledge about material and social technologies across several generations of traumatised people to a generation which is struggling to feed itself. George Stewart's novel, *Earth Abides,* captures these difficulties well.[8] Does one prepare an "Encyclopedia Galactica" as in Asimov's Foundation trilogy?[9] What might be the equivalent of the monasteries which kept "the flame of learning" alive during Europe's dark ages?

SLIDE PROBLEMS OF INTERVENTIONISM

Interventionism

I am inclined to label *Interventionism* as the "conventional wisdom" response to my Dark Age scenario. Its perception is that if we work cooperatively and intelligently we should be able to adapt to and mitigate the worst consequences of Global Overshoot with relatively little loss in quality of life. Conflicts over resources and disjoint world views can be resolved. Famines can be forestalled. Greenhouse emissions can be slashed through cooperative action. And so on. I am sure that much

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[8] George Steward (1949 (1999)) Earth Abides, Millennium London.

[9] Isaac Asimov (1995, 1996) The Foundation Saga (Foundation, Foundation and Empire, Second Foundation), Paperback editions, Harper & Collins, London.

can and will be done, but the task is enormous and, drawing on my understanding of human society as a combined evolutionary and ecological system, I can see two grossly under-recognised impediments to the success of this strategy. One, which I call the "virtual species problem" is that humans readily "speciate" into groups which have great difficulty in working cooperatively, e.g. Copenhagen, Israel. There is no "We." There are, to use Franzi Poldy's phrase, 'limits to agency.'

The other problem for Interventionists, already highlighted, is that human society is a complex system and 'We' do not understand how to manage complex systems, bedevilled as they are by pervasive circular causation and latent externalities. I have never heard of a politician admitting that all intervention is experimental.

What to do? What will happen?

While I have sympathy for all three ways of responding to my Dark Age scenario, none leads me to any conclusions about what, if anything, I, as an individual, should be doing about the Overshoot Crisis. As the title of my talk suggests, I remain a contemplative, not an activist. Perhaps what I have said might prove more helpful to others.

SLIDE ECOHUMANISM

Ecohumanism

But despite my professed passivity, I do have ideas I want to inject into this existential dialogue. In capsular form, what I am offering, under the label *Ecohumanism*, is a philosophy with two foci. One is a humanism based on quality survival. The other is an awareness of the evolutionary and ecological nature of the human situation---what I call *ecoawareness.*

I see it as extremely important that people keep at the front of their minds that what ultimately matters is not economic growth, or some other instrumental goal, but high quality of life for most people into the indefinite future.

Our ideas about ecology and evolution have been largely developed by studying the pre-cultural ecosphere, but these powerful concepts for understanding change (albeit, not predicting it) are equally applicable to a world experiencing Global Overshoot. Being aware of these dynamic ideas does not solve the "what-to-do" problem but does provide a perspective from which "what-to-do" suggestions stand to emerge (e.g. Why not cap energy use?) and from which such suggestions can be evaluated. Time precludes further discussion but, as an example, it is a perspective which suggests there is an urgent need to advance our understanding of how complex systems work and also our understanding of the roots of the "virtual species" problem.

While I am convinced that the Overshoot Crisis is real I am not convinced that it will turn into a Dark Age catastrophe. It would be unsurprising if it did but, equally, with lots of luck, and some increasingly desperate efforts as the juggernauts converge, we could "muddle through" with a bearable amount of pain.

SLIDE DO I HAVE A CONCLUSION?

Do I have a wrap-up conclusion?

I don't think so, just a question maybe.

How can Human-Earth System modelling and qualitative policy development be best integrated? Given the paucity of global policy machinery, and the difficulty of capturing many relevant processes quantitatively, should we even be trying?

APPENDIX: POWERPOINT SLIDES

Modelling the natural cycles of the human-earth system

A human ecologist's perspective

A talk in two parts

- Global modelling and global policy options
- A case study of the Global Overshoot Crisis

The Policy Swamp

- Why I am not a modeller
- The ‘tech-head monkey’ view of CSIRO
- Evidence-based policy or policy-based evidence?
- Hot-button issues can burn you

My world view

- I have a ‘Second Law’ view of the origins and evolution of the human-earth system
- Pantheon includes Chaisson (FERD), Swenson (MEP), Prigogine
- Reality = evolving nested hierarchy of dissipative systems in which energy flows and matter cycles (Ecology)
- Selective retention of variation (Evolution)

Workshop perspective

- Not about communicating research results
- Is about medium term dynamics of a world system (Ecosphere? Oikosphere?) which is sensitive to economic, social and political processes, as well as biological and physical processes
- ---and the interactions of all these
- When is a paradigm new?

What is the question?

- Is there an overall problem (goal?) for human-earth-system modelling?
- Understanding the system? Too vague.
- Why? Promoting sustainable development?
- [[My working answer later]]

What can global modelling achieve?

- A complex, dissipative and evolving system---makes it hard
- Partial models can be useful
- Models are ‘hypothesis generators’
- Other difficulties too (e.g. data, agency)
- Can’t generate global policy options but still has lots to contribute

Whence global policy options?

- Need policy responses to global scale ‘what-to-do’ issues
- No established procedures
- Construct and select from abductively plausible ‘if…then’ scenarios (narratives, stories)
- What are plausible goal-relevant consequences of intervention X?
- A modest methodology

Part 2 The Global Overshoot Crisis: A Case Study

- Working without a quantitative scaffold
- Assembling bits and pieces (bricolage)

A change in perspective

- ***Deep Futures****: Humanity's primary task is to build a better world*
- ***Global Overshoot****: Primary task for the foreseeable future should be cast in terms of defending what we've got, not improving on it*
- *Sandbagging the levees, not irrigating the desert*

Has an Overshoot Crisis begun?

- ***Crisis***---a system moving quickly towards a highly uncertain future.

- ***Overshoot*** ---one or more processes of cumulative change approaching limits (tipping points?) where a major reorganisation could be triggered. …finding you've gone somewhere you wish you hadn't.

What sort of crisis?

- *A quality survival crisis*
- *Humanity's master goal = achievement of high quality of life (QOL) for most people into the indefinite future, the goal I call quality survival*
- *Plausible scenario = a large and rapid drop in QOL across the world*

- *Crisis becomes catastrophe?*

Four overshoot processes

- Overpopulation
- Global overheating
- Overextraction of resources
- Over-connectedness---increasing socio-economic complexification, e.g. more interdependent world economy, less modular, more long chains, unstable, beyond rational analysis, information glut
- (Spillovers & externalities---not deliberate)

Scenario: Impacts on QOL

- Destructuring processes such as:

  ---deurbanisation (abandoned cities)

  ---deindustrialisation (shattered economies)

  ---depopulation (gigadeaths)

  ---deglobalisation (eg currency wipe-outs, declines in trade, liquidity, internationalism)

Scenario: A Dark Age Future

- Irrespective of good intentions, existing problems of war, poverty, injustice, inequity, environmental degradation and sociopathy will grow, not shrink.
- Under the combined effects of drought, famine, war, mass migration, poverty, disease, resource exhaustion and economic disruption, the world's population will start falling well before current estimates of a peak in 2070. Many indicators of quality of life, including life expectancy, will slump.
- In all countries, especially failed and war-torn states, it will become much harder for most people to meet their everyday needs. Women and children, the old and the sick will be most affected. Jobs will be few. Supply chains for basic commodities (eg food, fuel, medicines) will break. Barter will become normal. Inflation will escalate. Health, education, transport and police services will degrade. Power and water supplies will become unreliable or worse. Roads and other infrastructure will be poorly maintained. Crime and group violence will escalate. Violent protest and looting will be commonplace. Ordinary people will live in fear. Mental illness will be endemic. People will turn to authoritarian regimes for respite.
- In brief, cities everywhere will struggle to avoid becoming giant lawless slums. Rural populations will be vulnerable to marauders and incursions from displaced persons. Life will be an exhausting wretched struggle.

Three legitimate responses to a dark age scenario

- ‘Wait and see’…Empiricism
- ‘Stop fiddling’…Interventionism
- ‘Rise like a phoenix’ ….Reconstructionism

Empiricism

- Scepticism**:** Stance that people’s assertions need to be justified
- Readily hijacked by vested interests
- Remember the precautionary principle
- Wait a minute, wait a minute, wait a minute …..Bang

Reconstructionism

- Too late to stop the dark age
- A Noah's ark perspective
- Helping our peasant grandchildren subsist
- A window of opportunity, but what to do?
- Problems of shouting down the time tunnel
  ---"Encyclopedia Galactica"
  ---"Monasteries"
  --- *Earth Abides*

Problems of Interventionism

- There is no 'We'…virtual species problem…limits to agency…agonism

- 'We' do not understand how to manage complex systems…circular causation and latent externalities

Ecohumanism

- A philosophy for responding to the Overshoot Crisis
- Two components---Humanism & Ecoawareness
- My humanism = Quality survival= light on the hill
- Ecoawareness = awareness of the evolutionary and ecological nature of the human situation
- E.g. interest groups = ‘virtual species’ and new technologies = ‘mutations’

Do I have a conclusion?

- I don’t think so, just a question maybe
- How can Human-Earth System modelling and qualitative policy development be best integrated?
- Given the paucity of global policy machinery, and the difficulty of capturing many relevant processes quantitatively, should we even be trying?