Global Warming and the Gaia Theory - a Systems Approach

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Summary

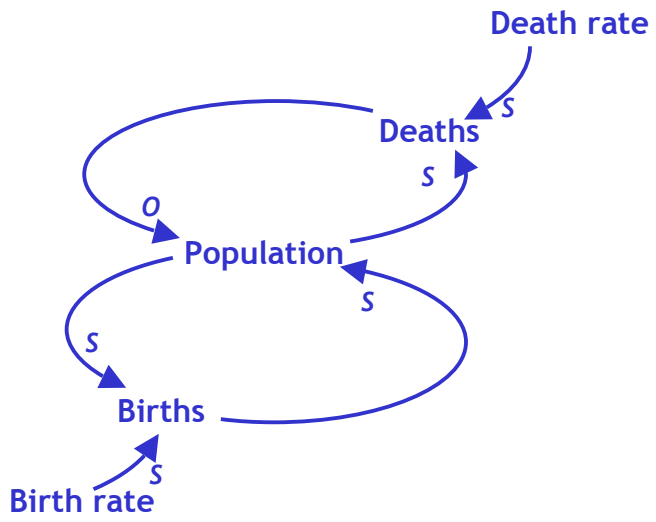
A recent report written for the US Department of Defence, authored by Peter Schwartz and Doug Randall, two of the world's leading experts in scenario planning, declares that the greatest military danger to the world as a whole – and not just the western democracies – is not terrorism, nor is it the possible use of weapons of mass destruction by rogue states. Rather, widespread, vicious and highly destructive military conflict is an inevitable consequence of the certainty of global warming.

Global warming has been discussed for many years, but there are still many people who are denial: they continue to claim that the current measurements of temperature increase are normal fluctuations, or simply manifestations of, for example, the long-term Milankovitch cycles associated with changes in the earth's orbit. And of those not in denial, many think that all we have to do (or better, all someone else has to do) is to cut back on a few car journies, so reducing the amount of carbon dioxide being pumped into the atmosphere.

The general level of knowledge of what global warming actually is, what its consequences are likely to be, and therefore about what can realistically be done to avert its most harmful effects, is woefully low. The report by Schwartz and Randall, and the associated publicity it is receiving, will surely help to shake people out of complacency. The purpose of this paper is to offer a small contribution to this worthy endeavour, and to incite the systems community to do likewise. For surely global warming is the example, *par excellence*, of why taking a systemic view of the whole, rather than a parochial view of the parts, is so important. A particular feature of my analysis is the incorporation of Gaia theory, James Lovelock's revolutionary concept of the entire globe as a system.

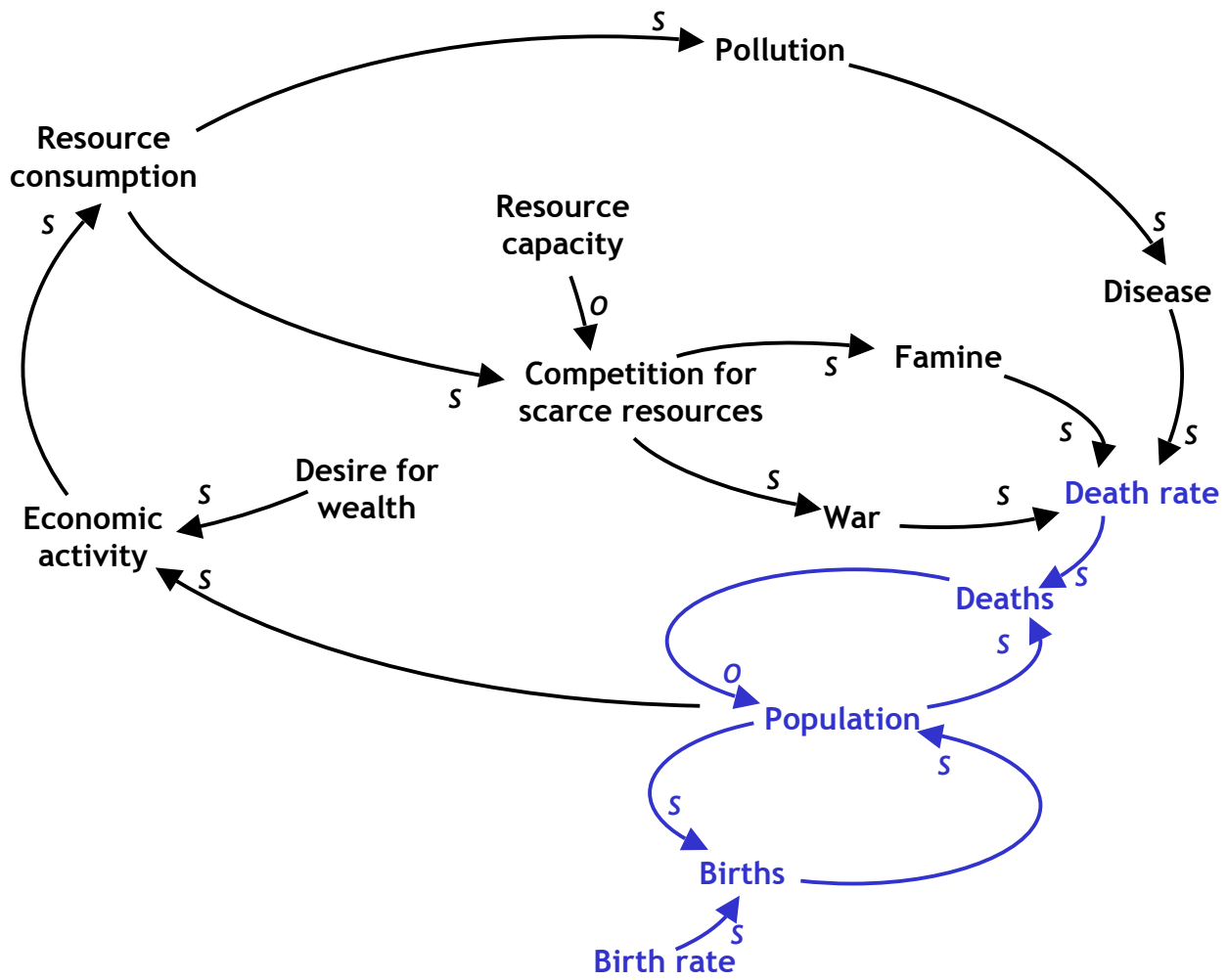
Population growth

My starting point is population growth. From a systems perspective, the *population* of the globe is determined by the dynamics of a reinforcing loop, driven by the *birth rate*, arrested by a balancing loop, driven by the *death rate*:



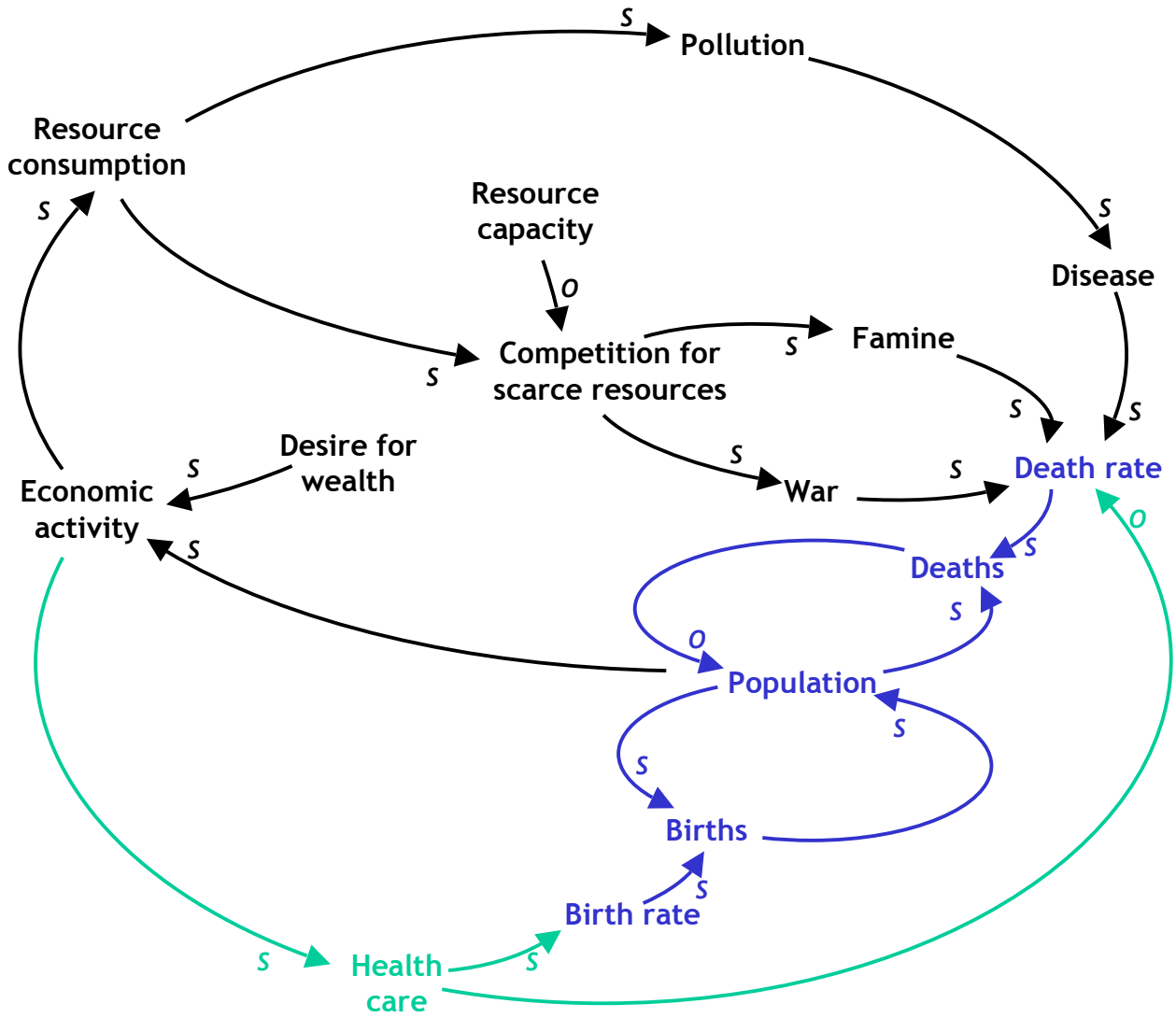
The *population*, motivated by a *desire for wealth*, drives *economic activity* and consequently *resource consumption*, which in turn leads to *competition for scarce resources*, from land to water, from gold to oil. At the same time, *resource consumption* gives rise to all sorts of waste products and harmful effects, which we can collectively refer to as *pollution*. *Pollution*, in its widest sense, is an important cause of *disease*, and *competition for scarce resources* leads to *famine* and *war*; and *disease*, *famine* and *war* all drive up the *death rate*.

This leads to a more complex systems structure, with the single reinforcing loop of population growth limited by three balancing loops, all driven by man's *desire for wealth* and constrained by the overall *resource capacity*. .

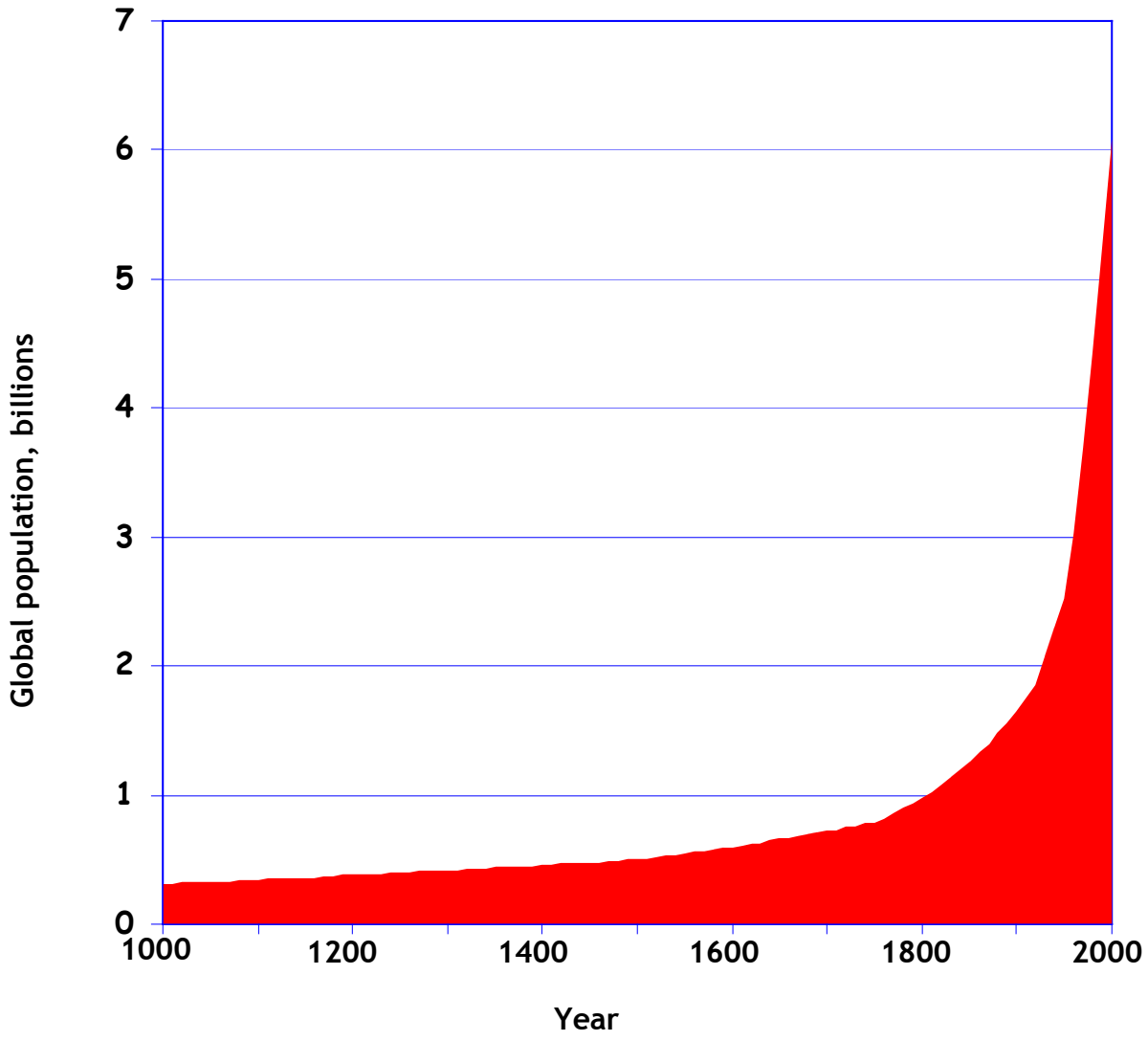


The natural constraints on population growth – disease and famine – combined with the unnatural constraint of war, each of which cause death, have been known for centuries. And no one captured the Four Horsemen of the Apocalypse more hauntingly than Albrecht Dürer:

For thousands of years, the Four Horsemen collectively kept the human population quite small. But around 1700 - 1800, something important changed: the cumulative surplus generated by *economic activity* provided the funds, the knowledge and the incentive to improve health care, both in terms of new public health programmes, such as the provision of safe water supplies and the treatment of sewage, as well as in terms of better medical care and the development of drugs and antibiotics. This had two effects: firstly, the *death rate* reduced, and secondly the *birth rate* increased, since women of child-bearing age became more healthy.

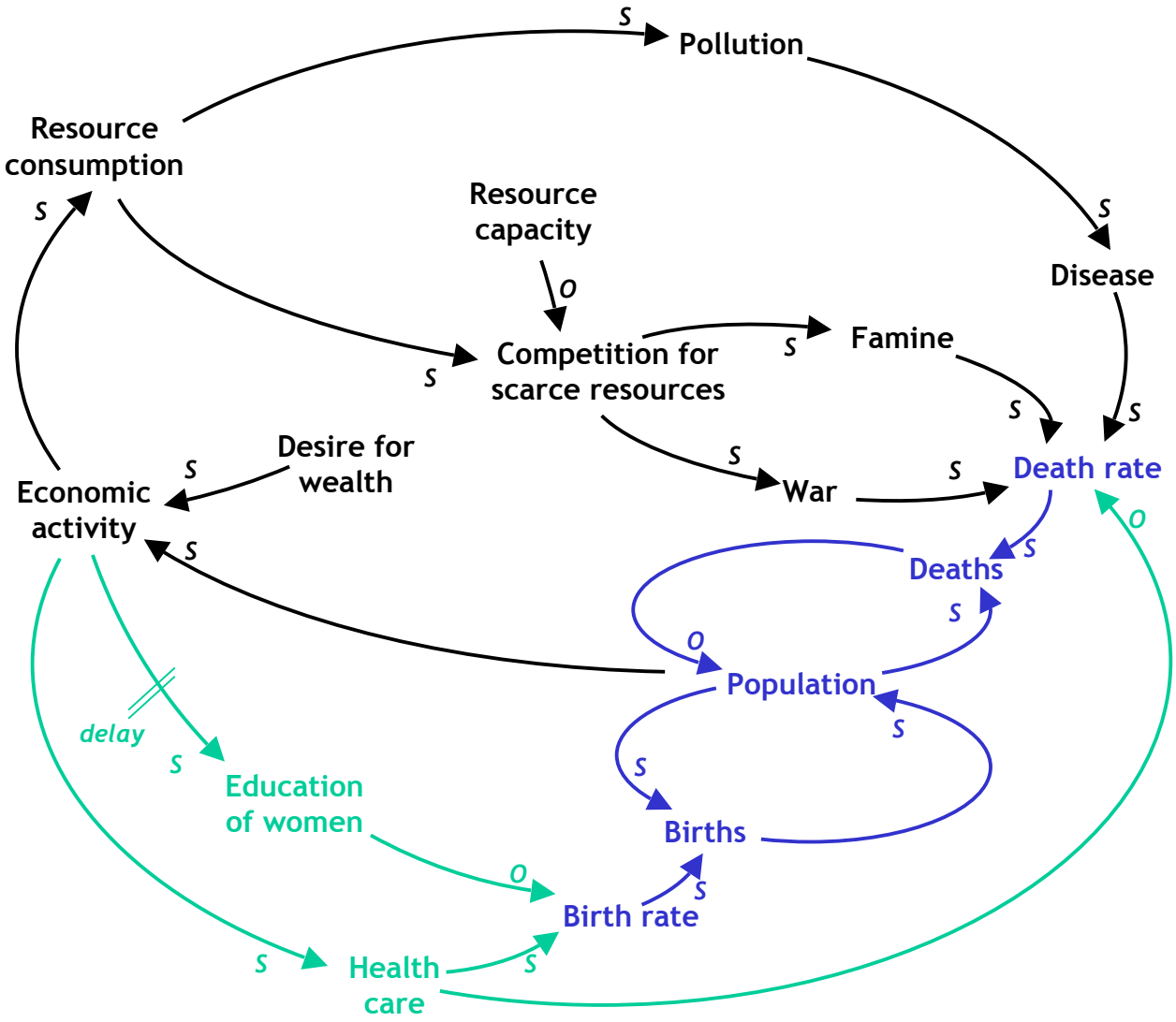


The simultaneous stimulation of the reinforcing loop and reduction in the braking effect of the main balancing loop caused a huge increase in *population*:



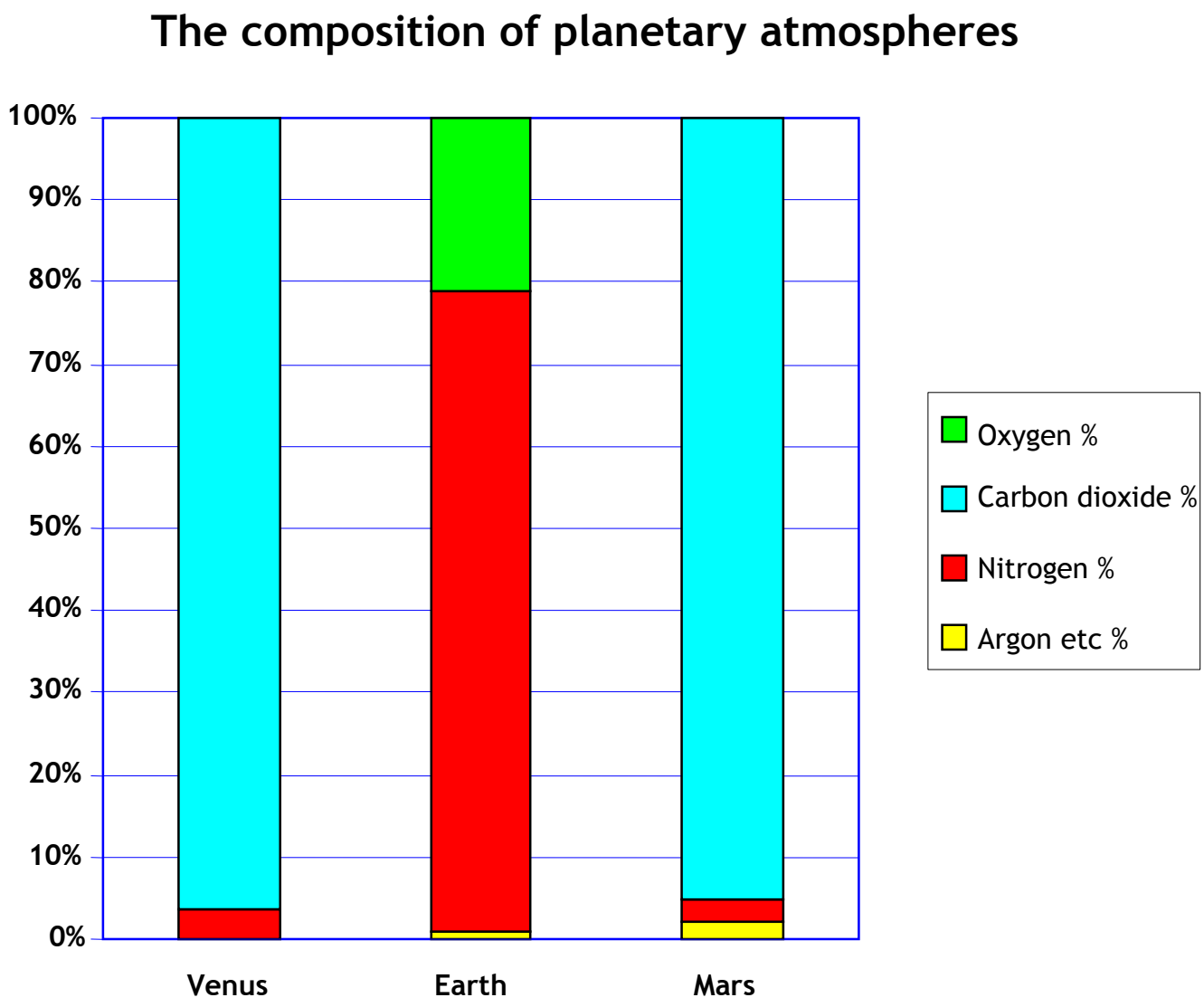
Source: The United Nations Population Division, Department of Economic and Social Affairs

How can the explosive growth of the global *population* be arrested? Current thinking is that the most powerful means of reducing the *birth rate* is by the *education of women* – but this can take a considerable time.



Gaia

During the 1960s, the young British scientist James Lovelock was working on the US space programme. His specific job was to think about how life on another planet might be detected either from earth or from a space probe. Lovelock's research soon focused on one particular aspect of any planet that might be studied from afar: the composition of the planet's atmosphere. This led him to study in detail some atmospheres about which quite a lot was already known: the atmospheres of Earth, and Earth's nearest neighbours, Venus and Mars. And when he did this, he noticed something odd: the atmospheres of Venus and Mars are rich in carbon dioxide, very low in nitrogen, and have no oxygen; in contrast, the atmosphere of the Earth has very little carbon dioxide, almost 80% nitrogen, and about 20% oxygen.



Lovelock also realised that the Earth's atmosphere, as we experience it today, is very far from chemical equilibrium, and geological evidence showed that this non-equilibrium state has been maintained for billions of years. Furthermore, his calculations showed that if the Earth's atmosphere were at chemical equilibrium, it would be very much like that of Venus and Mars.

Why is the Earth's atmosphere not in chemical equilibrium, even though literally billions of years have elapsed during which an equilibrium state might have been achieved?

Lovelock's answer is elegant and beautiful, and explained in detail in his books, notably *Gaia – The Practical Science of Planetary Medicine*. My one line summary is "The Earth's atmosphere is held in a dynamic, stable non-equilibrium state because the entire globe – its geology, its chemistry, its weather and its life – form one, unified, adaptive self-organising system; a system which both maintains, and is maintained by, life."

One key aspect of this global self-organising system – for which Lovelock coined the name *Gaia*, after the Greek Earth-mother goddess – is the maintenance of a relatively stable mean global temperature of about 14ºC over, once again, millions if not billions of years - even despite occasional ice ages.

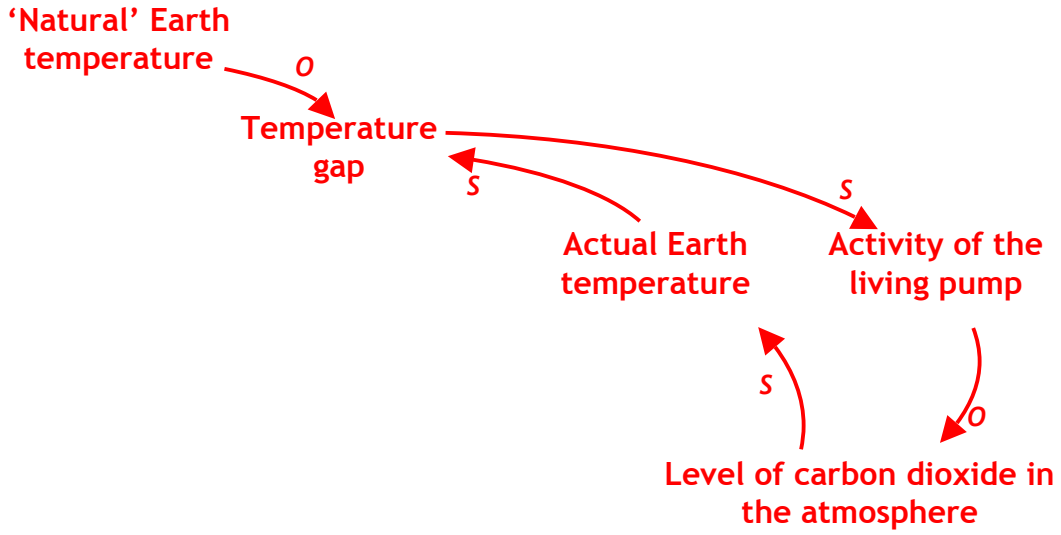
Over these billions of years, the sun has been getter hotter, and the Earth should have heated up. But it hasn't. What *has* happened, though, is that, as the sun has been getting hotter, there has been progressively less carbon dioxide in the atmosphere. Now carbon dioxide is a 'greenhouse gas', and hinders the re-radiation of the Earth's heat back into space. Carbon dioxide therefore acts as a 'one-way blanket', letting the sun's heat in, but preventing the Earth's heat from getting out. So, the more the amount of carbon dioxide in the atmosphere, the 'thicker the blanket', and the warmer the Earth; conversely, the lesser the amount of carbon dioxide in the atmosphere, the 'thinner the blanket' and the cooler the Earth.

What Lovelock determined, once again from geological evidence, is that, as the sun has been getting hotter, and so pumping more heat into the Earth, the amount of carbon dioxide in the atmosphere has been steadily decreasing, so allowing more heat out. And the rate of reduction of carbon dioxide in the atmosphere has been just what has been required to keep the temperature of the Earth constant. Constant over many millions of years. Just as if there is a balancing loop at work, controlling to a "natural Earth temperature", with the controlling mechanism being the amount of carbon dioxide in the atmosphere.

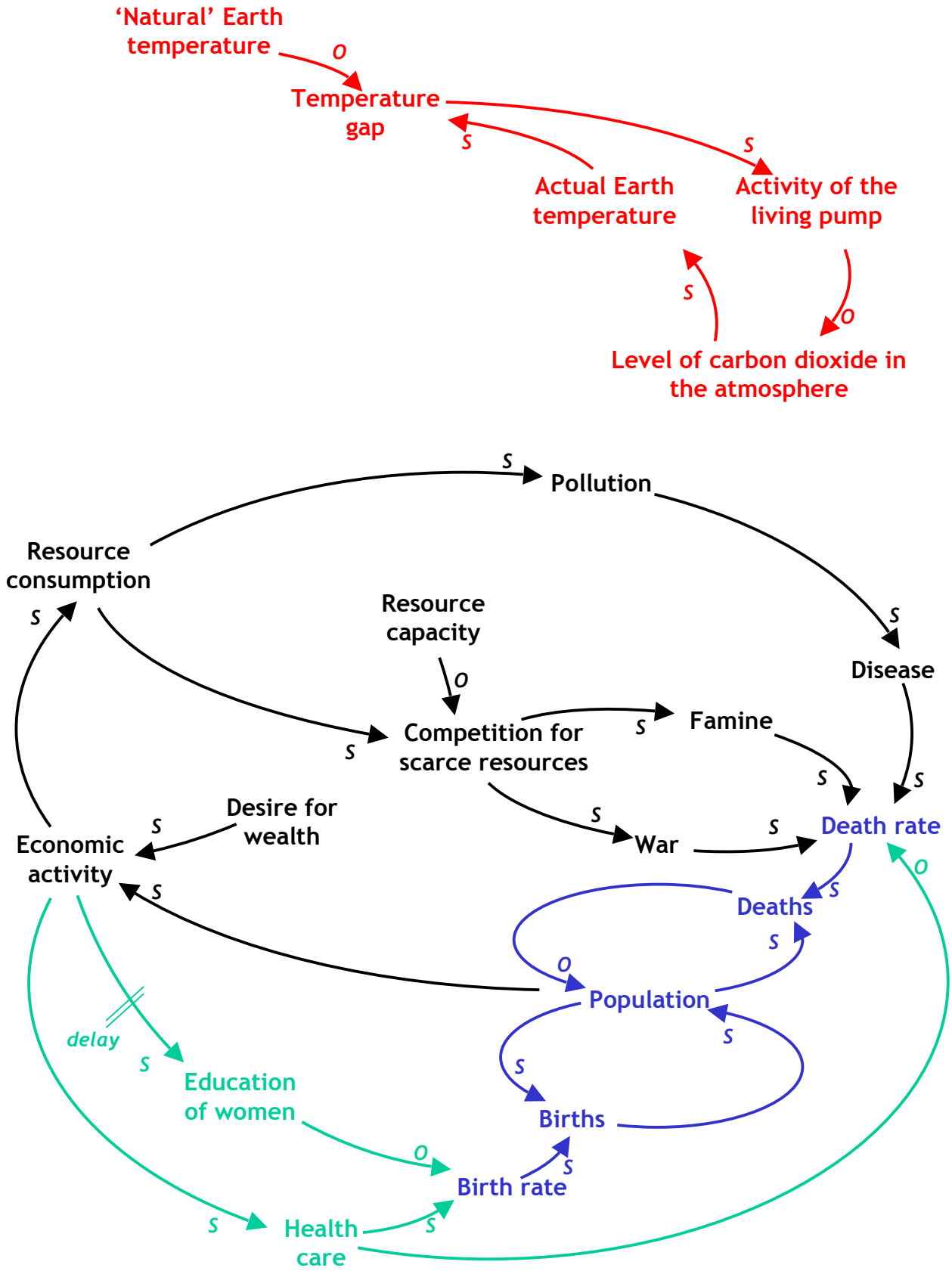
But the "natural Earth temperature" isn't just any-old temperature – it is the temperature at which live thrives. And life itself is the primary mechanism by which carbon dioxide has been steadily removed from the Earth's atmosphere, by a mechanism known as the 'living pump'.

Very briefly, carbon dioxide in the atmosphere is absorbed in water droplets to fall as carbonic acid in rain. This carbonic acid reacts with calcium silicate in rocks to form soluble calcium bicarbonate, which washes out in rivers into the sea. In the oceans, marine micro-organisms known as coccolithophores absorb the dissolved calcium bicarbonate to make insoluble calcium carbonate, the main structural component of their shells. And when these organisms die, their shells fall to the bottom of the sea, and become the rocks we call limestone and chalk. Yes, the origin of all the limestone and chalk in the Earth is atmospheric carbon dioxide, transformed into rock by a living process. A living process that has continued for millions of years, and that has served to keep the temperature of the Earth constant – so that the living pump could continue to work.

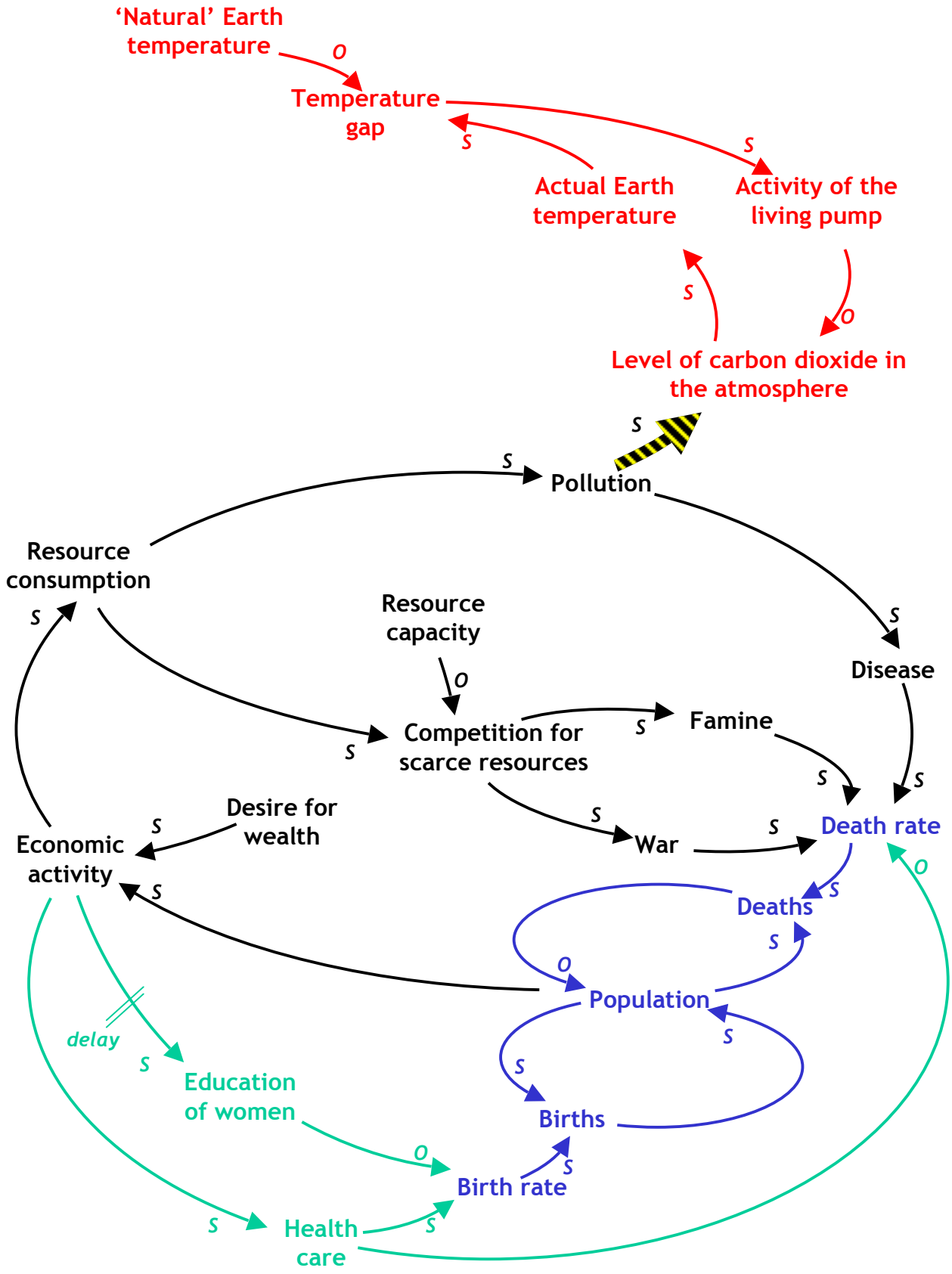
In systems terms, this is a balancing loop, mediated by life:



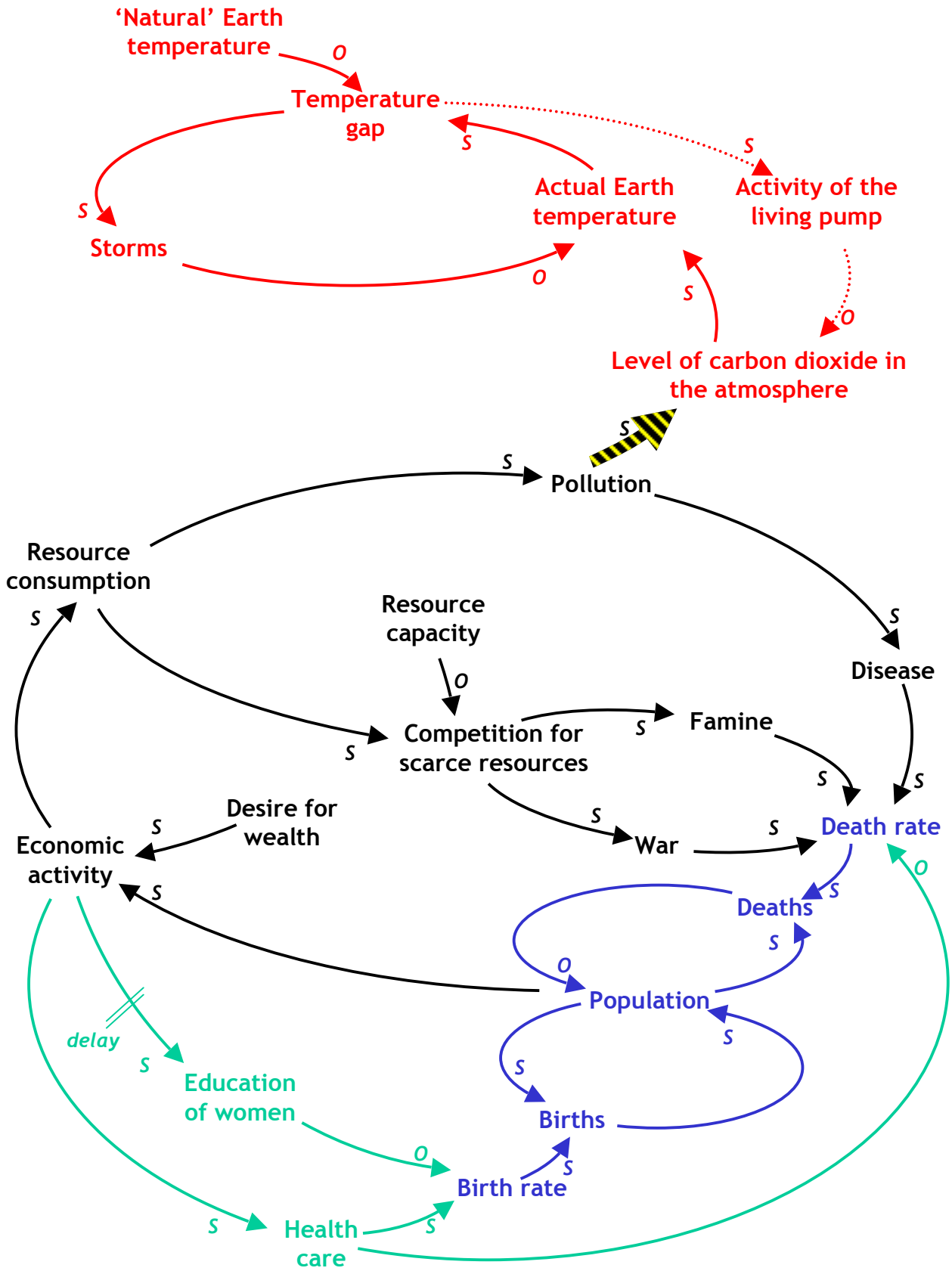
And for millions of years, Gaia's balancing loop operated largely independently of man's constrained reinforcing loop:



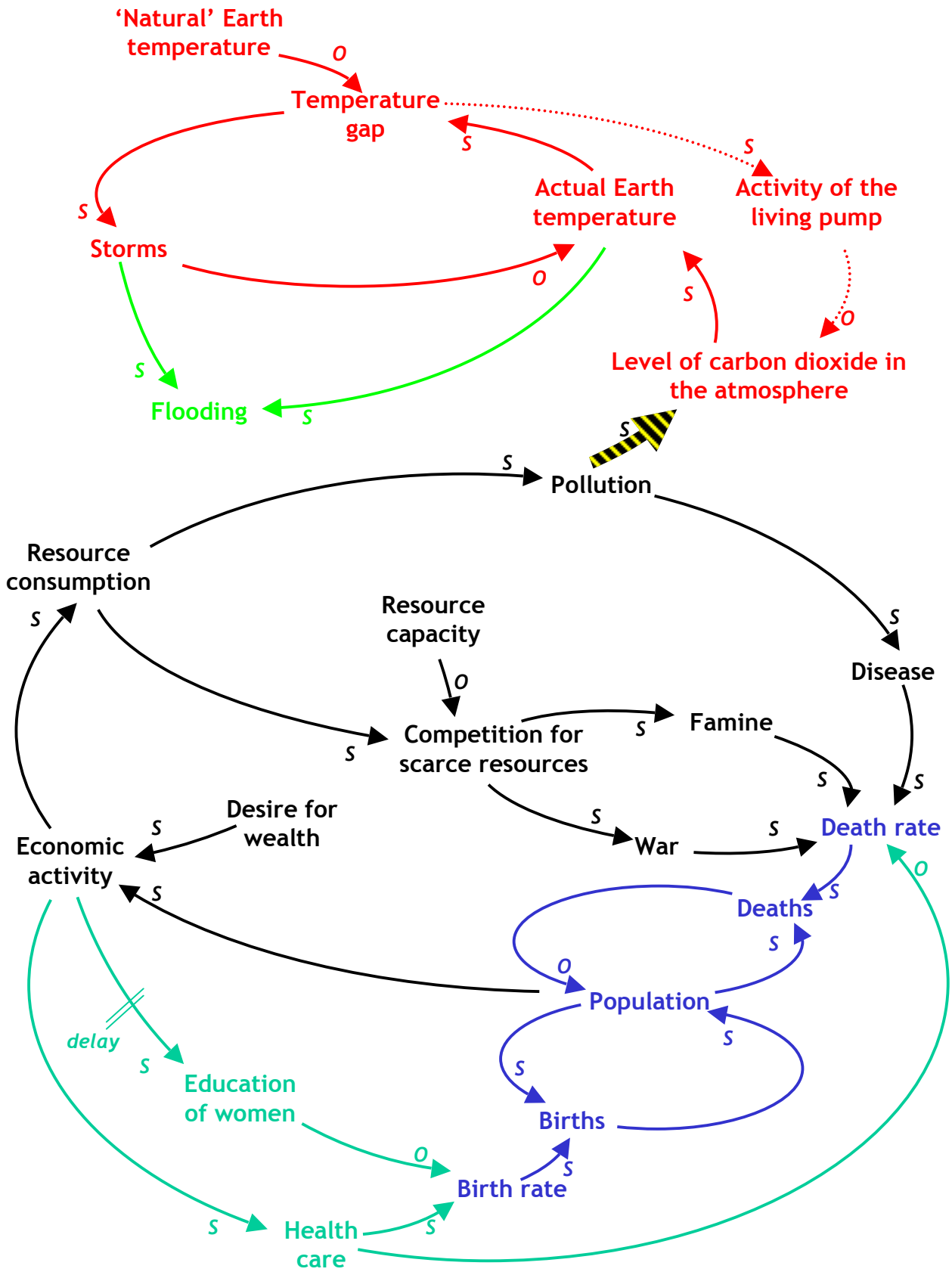
But as that reinforcing loop spins, the level of *pollution* increases, and one aspect of that *pollution* is the release of man-made carbon dioxide into the atmosphere. Sooner or later, man's activity is going to impact on Gaia:



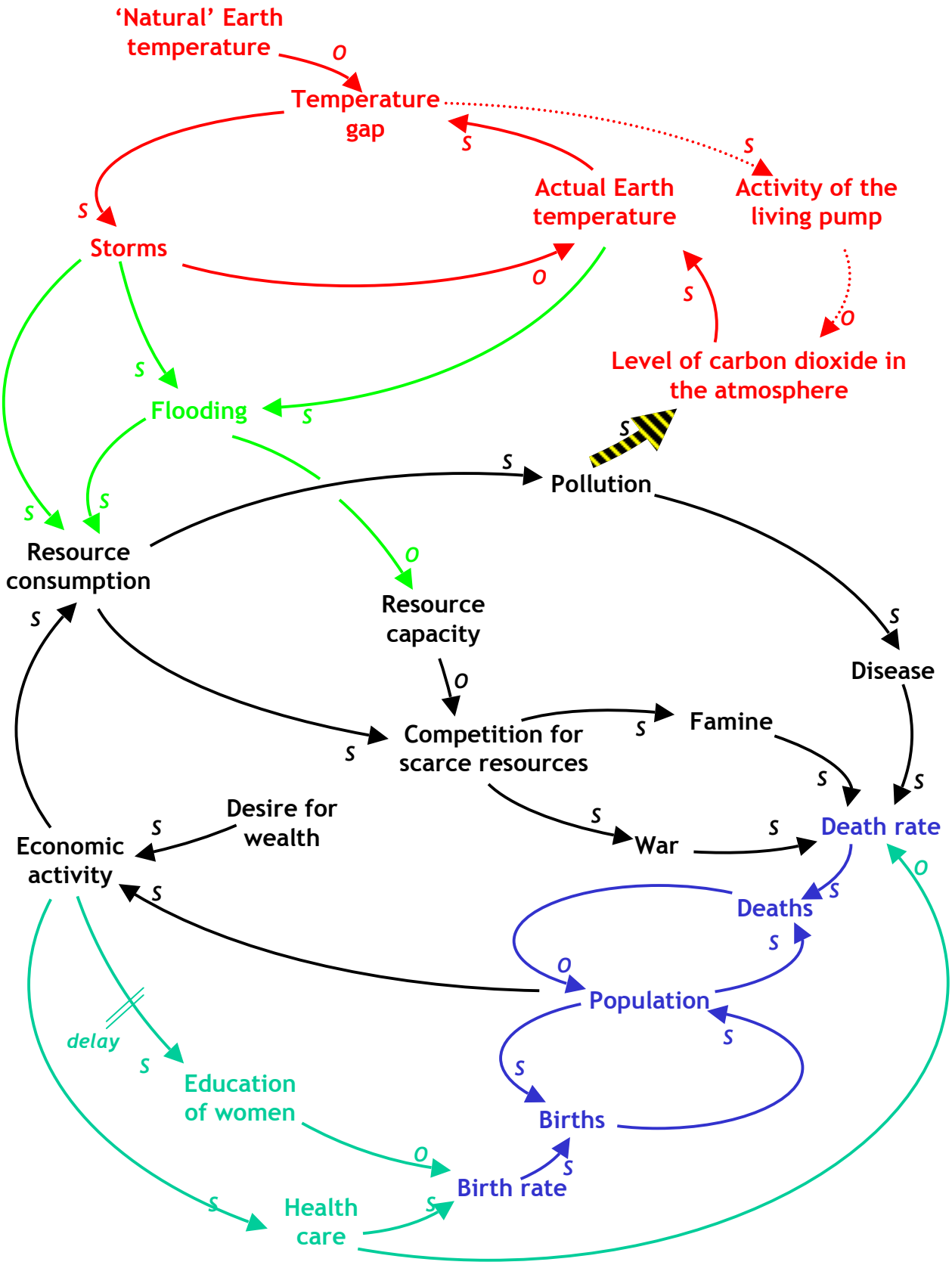
Gaia can withstand this for a while, but when the rate at which man-made carbon dioxide is pumped into the atmosphere reaches a certain level, the living pump can no longer cope. And if Gaia is to maintain the *'natural' Earth temperature*, it must invoke another control mechanism. What might this be? How might Gaia dissipate unwanted energy? By storms, that's how.



But *storms* are not the only consequence of a rise in the *actual Earth temperature*. The ice cap melts, and even more importantly, the sea level rises as a result of the thermal expansion of water. This causes *flooding*, as do the *storms*:



Flooding and *storms* cause an increase in *resource consumption*, as man seeks to prevent, and then fix, the damage. Furthermore, *flooding* will drastically reduce *resource capacity*, especially of resources such as agricultural land, cities and clean water:



The overall impact of this is to increase war, famine, disease and death, and the Four Horseman become whipped into a frenzy of destructive activity.

And the example of carbon dioxide is only one instance of man's activity interfering substantially with the Gaia's delicately balanced ecosystems – let's not forget methane, ozone and all the others that have a simiolar systemic effect.

And talking of systems, what's happening from a systems perspective?

Simple. A no-longer-strongly constrained reinforcing loop, that of population growth, is beginning to disturb the Gaia-driven balancing loop of global temperature control. And, as systems theory predicts, the balancing loop will seek to exert control, and will kick back at the disturbance. And if that disturbance happens to be man, so much the worse for man. Gaia, after all, has been sustaining life on Earth for around 3.6 billion years, whereas man has been around for only the last 350,000 years or so.

Gaia doesn't need man, but man surely needs Gaia.

And if man's reinforcing loop is pushing against Gaia's balancing loop, who is going to win?

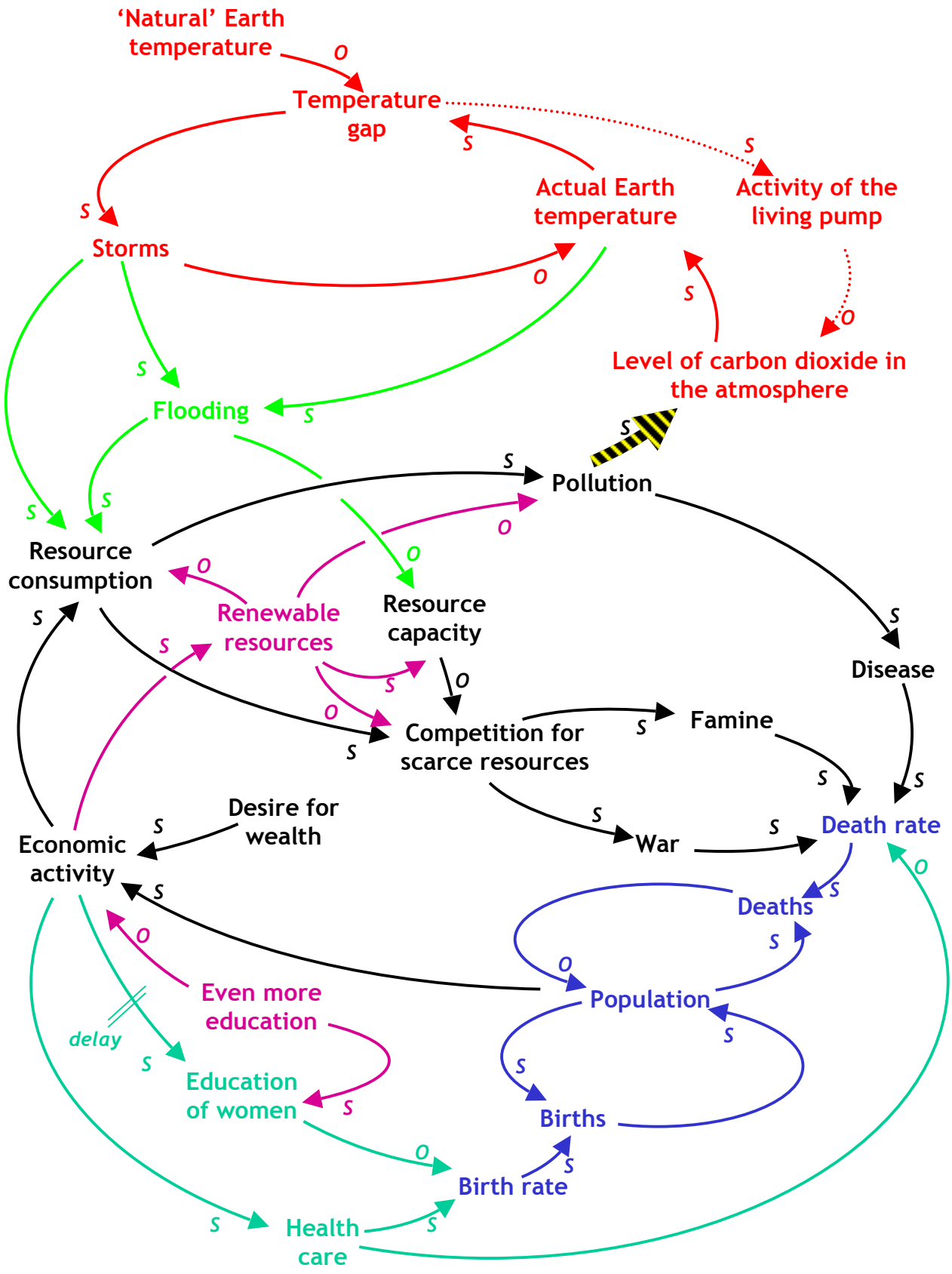
My vote goes for Gaia.

And in that case, there is one, and only one, policy: we have to slow the reinforcing loop ourselves, voluntarily. Before Gaia slows it down for us.

How?

My suggestions are shown on the next page: what ideas do you have?

And how can the systems community take the message out so that everyone understands, and commits their politicians to act?


'Natural' Earth temperature
Temperature gap
Actual Earth temperature
Activity of the living pump
Storms
Level of carbon dioxide in the atmosphere
Flooding
Pollution
Resource consumption
Renewable resources
Resource capacity
Disease
Competition for scarce resources
Famine
Desire for wealth
War
Death rate
Economic activity
Deaths
Even more education
Population
delay
Education of women
Births
Birth rate
Health care

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