**The global environment Boundary conditions Jun 16th 2012** 

**The idea of planet-wide environmental boundaries, beyond which humanity would go at its peril, is gaining ground**

PULL a spring, let it go, and it will snap back into shape. Pull it further and yet further and it will go on springing back until, quite suddenly, it won't. What was once a spring has become a useless piece of curly wire. And that, in a nutshell, is what many scientists worry may happen to the Earth if its systems are overstretched like those of an abused spring.

One result of this worry, in the autumn of 2009, was the idea of planetary boundaries. In the run-up to that year's climate conference in Copenhagen a group of concerned scientists working under the auspices of the Stockholm Resilience Centre, in Sweden, defined, in a paper in *Nature*, what they thought of as a safe operating space for human development—a set of nine limits beyond which people should not push their planet.

The nine areas of concern were: climate change; ocean acidification; the thinning of the ozone layer; intervention in the nitrogen and phosphate cycles (crucial to plant growth); the conversion of wilderness to farms and cities; extinctions; the build up of chemical pollutants; and the level of particulate pollutants in the atmosphere. For seven of these areas the paper's authors felt confident enough to put numbers on where the boundaries actually lay. For chemicals and particulates, they deferred judgment.

Since then, the idea of planetary boundaries has taken root. It crops up repeatedly in GEO-5, the United Nations Environment Programme's new assessment of the world. The High-Level Panel on Global Sustainability, which reported recently to Ban Ki-moon, the UN's secretary-general, gave the idea pride of place. And Planet Under Pressure, a big scientific conference held recently in London, made boundaries central to the message it sent to Rio+20, the UN environmental summit that opens in Brazil on June 20th.

**Don't fence me in**

Planetary boundaries provide a useful way of thinking about environmental change, because in many cases they give scope for further change that has not already happened. That has brought the concept friends who are not normally persuaded by environmental thinking, as well as green enemies who will brook no compromise. But the concept has numerous drawbacks. The actual location of the boundaries is, as their proponents acknowledge, somewhat arbitrary. That is partly because of the incomplete state of current knowledge, but it may remain so however much anyone knows. Some boundaries might be transgressed without irreversible harm occurring. Some may have been drawn around the wrong things altogether. And some academic opinion holds that spectacular global change could come about without breaking through any of them.

The latest criticism comes from the Breakthrough Institute, a determinedly heterodox American think-tank that focuses on energy and the environment. Among the points made in a report it published on June 11th, two stand out. The first is that the idea of boundaries does not focus enough on the distinction between things with truly global effects and those that matter primarily at a local or regional level. The second is that the planetary-boundaries group derives most of its limits by looking at conditions during the Holocene—the epoch since the end of the most recent ice age, in which human civilisations have grown up. Both of these criticisms have merit.

For things that clearly do have the springlike quality of shifting irreversibly if pulled (or pushed) too far, like the collapse of ice sheets or the melting of permafrost, a boundary system that seeks to stop you getting too close to the threshold seems as sensible as a safety rail is on a parapet. There is good reason to believe that parts of the climate do behave this way, and thus need railing off. But of the nine boundaries, only three apply to systems where the boundary setters really believe there is a global threshold: the climate; the acidity of the oceans; and the ozone layer. Some of the other six may have local thresholds, but for the most part their global effects are simply the aggregate of the local ones.

Confusing the two might, in the Breakthrough Institute's view, result in poor policy. Concern over a planet-wide nitrogen limit, for example, could lead to people forgoing the benefits that fertilisers offer the poor soils of Africa on account of harm done by their over-application in China.

The institute's other criticism is the implicit assumption that because mankind came of age in the Holocene, therefore Holocene conditions are optimal for the species now. There are indeed reasons to believe some aspects of the Holocene were optimal. It was a time of climatic stability and, in the temperate regions of the Earth, clemency. The Breakthrough criticism agrees that climate stability is a good thing. It points out, though, that there is little evidence things like the behaviour of the nitrogen cycle or the phosphate cycle in the Holocene were particularly well-suited to humans. The fact that people have used industrial chemistry to short-circuit the nitrogen cycle, by making fertilisers out of nitrogen in the air at a rate which greatly exceeds what natural systems can manage, has real environmental effects. Nitrate-rich run-off, for example, can wreck the ecology of lakes. But if these effects could be managed, then it is not clear that the amount of nitrogen being drawn out of the air would, of itself, be a problem.

This is, at bottom, an argument about the nature of the Anthropocene—the age of man. Many scientists feel that human interference in the way the Earth works is now so great that the Holocene is history and a truly separate Anthropocene has dawned. The planetary-boundaries idea seeks to constrain the Anthropocene within the norms of the Holocene. The Breakthrough Institute, by contrast, argues for ordering things according to a calculation of the needs of human welfare, rather than just aping what has happened in the past. There is no doubt as to which of the two approaches is more prudent, and prudence always has a constituency. There is plenty of room for debate as to which is more plausible, or practical.

**Independence declaration**

Another problem for the idea of planetary boundaries is the assumption that they are independent of each other. That seems unlikely, and if they are not then a crisis might arise even if no single boundary were transgressed. On June 7th *Nature*, which likes to get its oar in before big international powwows like the ones in Copenhagen and Rio, published a review of evidence that this may be happening. It suggested that the Earth may be approaching a “tipping point” past which simultaneous changes—to land use, climate and more—driven by an ever larger, ever richer human population, push the system into a very different state from its present one, with climate zones changed permanently, ecosystems functioning differently, and so on.

A sudden shift is plausible. Small ecological systems, such as lakes, often switch states in this way and there is no obvious reason why a large system like the Earth should not do likewise. And according to Anthony Barnosky of the University of California, Berkeley, one of the *Nature* review's main authors, a combination of changes, each itself within the planetary boundaries, could still trigger such a change of state.

That would be a bad thing. Even if the ultimate result were an Earth that is still hospitable to mankind, the transition could be catastrophic. But the existence of plausible bad futures within the boundaries raises the obverse question: are there good futures outside them? In particular, might it be possible to finesse the most famous boundary of all, the one governing greenhouse warming and climate change?

The planetary-boundaries team, slightly confusingly, defines this boundary in two different ways. One is a limit on carbon dioxide, the main long-lived greenhouse gas, of 350 parts per million (ppm) in the atmosphere. The other is a limit on “radiative forcing”—the increase in energy delivered to the surface of the Earth over time, largely as a consequence of extra greenhouse gases—of 1 watt per square metre above pre-industrial levels. Either way, the climate boundary is one that already lies squarely in humanity's rear-view mirror. This reflects the view of some on the planetary-boundaries team, such as James Hansen of the Goddard Institute for Space Studies, that today's climate is already beyond the point which can guarantee long-term survival for things like the Greenland ice sheet, the demise of which would raise sea levels by seven metres.

If the planetary-boundaries scientists really have got their sums right, the greenhouse-gas situation looks hopeless. From today's position of carbon-dioxide levels pushing 400ppm and going up about 2ppm a year, a carbon-dioxide level of 350ppm can be reached only by going to zero emissions and then spending a long time—centuries, in all likelihood—sucking CO2 out of the atmosphere and putting it back underground by various means.

**Force majeure**

Greenhouse gases are, however, only a problem because of their effect on radiative forcing. If that could be reined back inside the boundary by other means, then the CO2 limit would no longer pertain. And that might be possible by spraying reflective particles into the upper atmosphere, to bounce sunlight back into space.

Such a radical scheme would have all sorts of disturbing side effects, with political ones quite possibly outweighing environmental ones. It is by no means clearly the right thing to do. But it might be. And it certainly serves to show that, although the Earth may have boundaries, thinking about how to help it should not.

    